University of Dundee

MASTER OF SCIENCE

E-learning and developmental osteology
a test of suitability

Tyldesley, Katie

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CONTENTS

Tables and Figures

Chapter 1: Background

Chapter 2: Materials

Chapter 3: Method and Discussion of Methods

Chapter 4: Results

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Declaration

This thesis is a recording of results obtained through experiments performed by myself, in the Centre for Anatomy and Human Identification, University of Dundee. Data collection and analysis was carried out under the supervision of Professor. Sue Black between October 2007 and December 2008. It is my own work and has not been previously submitted, in whole or part, for a higher degree.

Katie Tyldesley

Abstract

Advances in technologies such as the Internet have shown a rapid increase of courses offering online supplements or being taught entirely online. The development of the skeleton has not as yet been approached as a subject taught online. The University of Dundee considerable expertise in this area, and houses the only known active repository of juvenile skeletal remains, and consequently it was proposed that this subject area should be assessed for its suitability for online teaching.

A test module was created on the development of the "hip" bone in which 145 students and staff from the Centre for Anatomy and Human Identification were enrolled. These participants were tested on the content of the module prior to access, and these results were compared to those received following completion of the module to highlight any improvements. In addition to this, evaluations were taken throughout the completion of the module in order to gain participants opinion of the module and its suitability for teaching.

Overall, results demonstrated understanding as scores improved following completion of the online module. Evaluations were largely positive with a number of suggestions for improvement. Although participants found the module a useful revision tool, it was not supported as an alternative to traditional face-to-face teaching.

Further developments to the test module should be made in order to produce a more interactive learning experience which would be suitable for teaching. Following the tentative success of the test module, the remaining skeleton could be addressed in the future. Further expansion into other areas of forensic anthropology could also be considered which has the potential to expand further into the vast subject of forensic science.

Chapter 1.

Introduction

The introduction of internet resources to academic subjects has resulted in rapid changes to the discipline of learning and teaching worldwide (Ryan *et al.*, 2000). Traditional face-to-face methods of teaching are being supplemented, and in some cases supplanted, by additional online information, technologies and resources due to the internet's flexibility, accessibility and communication features (Ryan *et al.*, 2000). As internet availability increases, (by 10% per month) the technology accessible to instructors worldwide is also advancing (Alexander and Boud, 2002). This, along with continuously improving communication applications, has increased the potential for the dissemination of learning and teaching material on a global basis through online distance learning.

It has been stated that the internet represents the greatest communication medium ever created (Jolliffe, *et al*., 2001). Due to its extensive and pervasive reach throughout the world and its ever increasing popularity and affordability, it is accessed by over six billion users worldwide. Since 2000, the global population of the internet has grown by 305.5%; with regions such as the Middle East and Africa increasing its internet usage by over 1000% (Internet Usage Statistics, 2008). In addition to the internet being utilised for personal and business reasons, users are now looking into the internet as a tool for learning.

The internet is *"principally a mechanism for the exchange and distribution of information"* (Jolliffe, *et al*., 2001, pp. 3), which has been recognised as a powerful medium for delivering learning and teaching materials. Academic institutions have recognised the potential for the internet as a tool not only for delivering academic

information, but have also observed the potential commercial gain from expanding its academic reach. This market is rapidly being exploited by a variety of commercial companies in addition to school and higher education institutions, who have taken advantage of the learning benefits of the internet to increase their student base, adapt to student demand and reach students who once were inaccessible (Turner, *et al*., 2004).

E-learning (i.e. electronic learning, online learning, and web-based learning) can be described as any means of teaching that utilises computer technology to enhance the learner's knowledge and performance. In the past 30 years, e-learning has been used to deliver learning in the form of mini computers, PCs, multimedia objects and more recently the internet has been the catalyst for increasing emphasis on the future of learning (Shaw, 2002). Today, e-presence through website occupation is currently at the core of many university profiles. Websites are often the first point of contact for staff, current and future students in addition to researchers and the general public. E-learning has many identities; it can range from a simple short course instructing the consumer on how to use its product, to the complexity of a full university degree (examples page 18).

The potential of the internet as a medium for the dissemination of academic material is now widely accepted and pursued by an increasing number of institutions as witnessed by the influx of online courses in the past ten years (Sonwalkar, 2001; Kerr, *et al*., 2006). A simple online search (using www.google.com) for a subject of interest will generate a number of available courses on that subject taught online. For example searching, "piano lessons online" will produce a number of "hits" to websites which will provide piano lessons for individuals to follow online (without face-to-face

interaction). Languages, art and craft techniques and science subjects also generate a number of "hits" giving available websites to courses which are commonly free. Academic searches for courses online show similar results. For example, searching "English literature online course" gave a number of courses which are 100% internet-based offered at universities such as The University of Oxford (UK), London School of Journalism (UK) and Southern New Hampshire University (USA). For a fee, these courses offer university credits and in some cases degree qualifications.

In an academic environment, e-learning has adopted the internet as a medium for distributing teaching materials which allows students to study courses and attain qualifications online. E-learning offers extensive learning opportunities for students as it gives them access to the vast knowledge and information encompassed by the magnitude of the internet. Greater communication opportunities via various online tools (e.g. e-mail, discussion fora) are also available which improve support facilities for distance learning courses. E-learning provides flexibility, creating greater student independence, allowing students to mould their learning to suit their own requirements (Peters, 2000). However, discipline and time management skills are fundamental qualities required by a student undertaking an online course. Therefore it is recognised that this is not a style of pedagogy that may suit all learners as it demands an element of maturity of approach (McIsaac and Gunawardena, 1996).

The availability of internet-based courses on a wide range of subjects indicates how extremely successful e-learning has become. Not only are universities enabling a wider student base, but they are also meeting demands of users seeking flexibility in their studies. Although e-learning methods of teaching will not suit all learners, its diverse flexibility aims to address a wide range of styles. In the near

future it can be assumed that with the introduction of new learning technologies, paired with the growth of the internet and communication facilities, the face of learning and teaching has the potential to continue to evolve encompassing a wider audience and offering greater choices for learning, (Peters, 2000; Ryan *et al*., 2000; Harden and Hart, 2002; McKimm, *et al*., 2003).

1.1: Changes in Higher Education

Traditionally, universities have taught degrees on a face-to-face basis where generally, students attend lectures and complete coursework using text book and journal references. The creation of online academic search engines (for example Scopus™ and Science Direct®), electronic referencing programs (for example EndNote®), and textbooks and journals are becoming readily accessible in an online format. As a result, today's students are expected to utilise the internet in their studies and are comfortable with the medium. Traditional methods however are not necessarily being entirely replaced, the internet is viewed as an additional source to enhance academic study whether for course work or further reading purposes (Turner, *et al*., 2004).

Online learning has been adopted by a growing majority of universities where tools are available for a range of learning and teaching experiences. At present, it is possible to attain a bona fide degree (or credits towards a degree) at higher education level without leaving the comfort of your own private space (O'Leary and Ramsden, 2002). However, the validity of a degree must be researched as courses available online do not always result in an accredited qualification which can lead to problems when seeking employment.

The Open University (www.open.ac.uk) was the first successful distance teaching institution of higher education in the UK. Following its introduction in the 1960s it utilised a number of advancing technologies to deliver high-level education off campus. Audio and video cassettes from the 1970s were supplemented and replaced by CD-ROM in the 1980s and, in more recent years, courses have introduced various internet features for delivery, communication and administration.

Delivery

Distance learning takes students away from the classroom (where they must attend class at a certain time and place). Distance learning gives students personal flexibility by having the opportunity to learn anytime and anywhere (Rosenberg, 2001). This advantage has been enhanced further with the introduction of online features as the delivery of a course on the internet offers a place for learning and teaching which can be accessed worldwide from any computer connected to the internet at any time.

Although many courses are password accessible, issues of fraud can be raised as instructors cannot guarantee the user accessing the course is the person enrolled on the course. Issues for safeguarding courses can be addressed by including security questions and entering personal details in addition to giving passwords to gain access to a course. Security of online courses can also be approached through e-mail links, where users gain access to the course after following links contained within an e-mail. Passwords, personal information and secure links however all rely on users not giving others their personal details (or information is leaked), and the subject of fraud may always be an issue with distance learning.

Communication

Online communication tools have improved distance learning significantly as peer, tutor and institutional interaction is available in a number of ways including; e-mail systems, discussion boards, video conferencing and pod casts. Traditionally, distance learning courses were paper-based and involved little communication between the student and instructor and often students could not interact with one another. Communication has now become a social part of distance learning and in turn become an independent culture, where it is acceptable to communicate online. Distance learning has benefited from the inclusion of internet communication tools as it provides interaction where it was not previously available. This may be seen as a disadvantage as face-to-face interaction will be reduced.

Administration

Early introduction of the internet into higher education institutions involved the use of e-mailing systems and instructors providing guided search links to the web for further reading. Today, the internet can be used as an administration tool to track student performance, store student records, grades and reports, and as a tool for coursework to be submitted and stored online via online drop boxes. The inclusion of these tools has improved distance learning as student information is readily accessible and easily tracked. However, disadvantages are heightened if there are server issues such as internet crashes as information and reports can be lost if they are not backed up regularly (Sonwalkar, 2001).

1.2: VLE A platform for e-learning

The use of virtual learning environments (VLEs) has been the means by which universities have embraced e-learning as a method of teaching. A VLE would be more appropriately described as a Virtual Environment for Learning as it is essentially the medium by which virtual education is made possible. It is the presentation and development of a virtual environment through which pedagogical endeavours can be presented. In 2002, it was reported that approximately 86% of UK educational institutions were using some form of VLE to communicate with staff and students (Urquhart *et al.*, 2004) and the prediction was that the percentage would continue to rise and institutions would continually advance their VLEs to utilise new or improved features offered.

A VLE in its simplest form is a software product which supports the delivery of learning and teaching materials online. A set of learning tools are made available within the academic environment to allow students to take some control over their learning process (Schulte-Mecklenbeck, 2004). The role of a VLE can be supportive, educational, and administrative (Ellaway *et al*., 2004). Typically VLEs include; communication, educational and administration facilities (Table 1), and can improve communication, enhance education and allegedly decrease the level of administration in an academic environment (Urquhart *et al.*, 2004).

Communication features	Educational features	Administration features
Email	Online assessment	Password access
Discussion board	Course documents	Student grade books
Video conferencing	File sharing	Marking software
Frequently asked question section	Lab work / practical classes	Tracking software
Feedback / evaluation forms	Reading lists	Calendar

Table 1: Common features found in a VLE

A simple webpage, where timetables, reading lists and links can be accessed forms the basis of a template for a module on a VLE. These can extend to the use of more detailed applications which take advantage of the available communication tools, interactive media, web links and other tools which may further engage the learner using features which accommodate individual learning styles. These resources can be developed to meet the needs of individual institutions, courses, instructors and students.

Blackboard™ (www.blackboard.com), following its merge with the former WebCT™, has recently become one of the largest service providers for VLE software in the academic community. Since its introduction in 1997 over 2200 institutions in 60 countries have adopted its software to provide an educational link between people and technology in schools, higher education institutions, corporate and government organisations in addition to textbook and journal publishers.

Blackboard™ aims to increase the uptake of e-learning materials into higher education institutions, engage students with individual learning experiences, and allow file sharing and collaboration in addition to

providing facilities to assess and analyse student performance. Other examples of VLEs include Moodle™, Open Source, Bodington™ and Edusim™. Generally, these are all capable of a range of interactions in the delivery of academic content made available online.

These products are simple to use as there is no prior requirement for HTML or computer programming experience; however some basic computer knowledge is beneficial. Blackboard™ provides a "what-you-see-is-what-you-get" (WYSIWYG) feature which allows educators to input academic material online without requiring prior web creation experience. This feature also enables instructors to choose the tools they require for their course to allow individual, efficient delivery of their academic material. To avoid overloading students with every tool available, instructors must choose those appropriate for their course. Modules can be created within the VLE which are password protected allowing enrolled students to have access to the material they require individually, in a controlled environment. Instructors also have the facilities to update the information and tools available and track and store student progress securely.

The Learning Centre at the University of Dundee has created a way to link Blackboard™ and make it compatible with a virtual assessment package; Questionmark™ Perception™. This has enabled assessments to be accessed in a secure environment and retains the analytical software within the assessment package. It also allows instructors to save grade books and track student progress confidentially.

VLEs used within universities require significant technical support. Instructors may have little knowledge of what opportunities their institution's VLE gives them and therefore a support team is often available to aid instructors in the implementation and smooth running

of e-learning facilities. Without the appropriate support, a VLE may be difficult to maintain (Schulte-Mecklenbeck, 2004); in some cases, universities require entire departments dedicated to the running of technical support to the VLE. Dr. Parsons from the University of Dundee's Learning Centre is the director of a support team of 15 people who aid instructors in numerous aspects of online learning, from creation to management, assessment and evaluation. The support from the Learning Centre is vital for the University's e-profile, strategy management and operations (Pers comm. Benwell, 2008).

The VLE system potentially has the ability "*to dominate or perhaps replace the traditional classroom as we know it*" (Galloway *et al*., 2002). However, VLEs have often been reported to "*stick at the initial stage of implementation*" (Urquhart *et al.,* 2004) due to a lack of communication and understanding between technological departments and staff, who are perhaps not aware of the full operational benefits of these systems. Urquhart *et al.* (2004) report that the full benefits of VLEs were not made clear to university staff members who were interviewed regarding their experience of working with VLEs. It is important to keep staff up to date with technologies used within their university to enable them to take advantage of these available resources to improve learner experiences.

1.3: Need for Lifelong Learning

Jolliffe *et al.* (2001) reported that 50% of information will be lost in 5 years by the average learner, suggesting that knowledge is often lost or becomes obsolete without active redress of reinforcement, expressing the need for lifelong learning. Learning from experience is essential for effective learning as students need to engage with the content in order to learn from it (Alexander and Boud, 2002). Therefore, e-learning (or learning in general) should not be a passive act.

Although lectures are readily accepted as a way to expose students to expert information effectively they have been accused of encouraging passive learning (Brooks, 1997). Passively attending lectures (where you cannot always guarantee the learners are engaging) and reading text-books (where the information presented may not be fully understood), may not be the ideal method of delivering information to all learning styles. These methods work well with self-regulated learners who are motivated, active listeners who take notes. However, inactive, unmotivated learners may not be effectively engaging with the content and fully understanding the information given.

Today, lectures can be made available by a number of media including; Microsoft® Office PowerPoint presentations, voice recordings, video linked conferences, discussions and interactive media which have been developed to accommodate a wider range of learning styles and abilities (Markland, 2003). Text based activities, imaging, interactive objects, voice objects, discussions, links, e-journals and textbooks are examples of different methods of teaching that also reach different learning styles.

Addressing a number of learning styles gives students the opportunity to learn freely through their own experience and engage with the presented content which can be approached via several media. It is essential for courses to adapt to these to effectively engage the unique requirements of each learner individually. Qualitative analysis by Urquhart *et al.* (2004) revealed that students found individualisation (created from e-learning) to be important for their own personal learning, progression and enduring commitment. Instructors, on the other hand, commented on concerns regarding the future need for face-to-face lectures if the content of a lecture was made available in Microsoft® Office PowerPoint format prior to presentation of the face-to-face lecture.

Although students unable to attend lectures have the appropriate materials if the presentation is posted online before the lecture, instructors felt attendance dropped in their classes as students chose not to attend lectures as they had previously been given the relevant materials. Students however, reported that they need interaction rather than re-presentation of materials (such as Microsoft® Office PowerPoint presentations) reporting that having the PowerPoint presentations before their lecture helped them prepare and take notes within their lecture. They also reported the use of multimedia features and face-to-face explanation was more useful when illustrating complex concepts (Urquhart *et al.*,. 2004).

Increasing interactivity, engaging learners and giving them control of their learning is key to an effective method of learning. Including multimedia features (such as animations) onto a VLE allows educational content to become interactive. An example of this has been seen in the International Virtual Medical School (IVIMEDS http://www.ivimeds.org/) where they have included drag and drop images and other activities in a password protected environment

online to teach medical students aspects of their course (discussed further page 22).

Activities accessed online such as animations can improve learning as they can be repeated (with or without sound) until the concept is understood. These activities have also been reported to create a more meaningful and memorable learning experience for students (McKimm *et al*., 2003; Urquhart *et al.*, 2004) as students can pace their learning and repeat complex material.

Animations can be simple 2D images played together to show objects from different viewpoints. More complex animations using virtual 3D objects give students the opportunity to interact with the object in a similar way to having the object in their hand. This is useful when explaining complex features on 3D objects as students can move the digital objects to any desired position on screen for improved understanding of spatial interrelationships.

Text can also be made interactive by including voice recordings, used in conjunction with video clips, allows students to start and stop and listen to text content at their own pace with the ability to replay it, which is not possible (without Dictaphone recording) in a face-to-face lecture situation. Using interactive media creates learning experiences which can be used in conjunction with text documents and other static materials (printable documents) attracting a number of different learning styles.

Distance learning is rapidly changing, where a once paper-based alternative to face-to-face learning is now pursuing independent online features to enhance learning experiences. Although there are many opportunities for traditional methods to be adapted for online delivery, the suitability for adaptation must be addressed before

online activities are implemented to ensure appropriate conversion and use online.

1.4: Suitability of e-learning

E-learning is not necessarily the most appropriate medium for all learning programmes and therefore it is essential to consider the suitability relating to a particular subject before supplementing it, or indeed replacing it with online alternatives. Although there is little systemic research into the impact of e-learning within a field of study (Tucker, 2001), several problems have been documented in individual cases. For example, O'Leary and Ramsden (2002) document training to be a major problem when implementing online alternatives to traditional face-to-face teaching.

In their case study, a instructor gave positive feedback to converting her course to an online format, but stated that a lot of time was taken up by learning how the VLE platform worked in order for the course to run smoothly. A number of students had commented on the course as being disorganised and it was suggested that the course should have been tested on a colleague before students were given access to avoid this problem. The instructor also suggested it would have been beneficial if a support team was contacted during the creation process. They would have provided information and training regarding the creation and implementation of online resources to ensure an organised, efficient learning experience.

Tucker (2001) also reported that poorly organised courses can lead to difficulties for the end users (students). For example, long lists of journal articles and required reading lists may deter the student as there is a clear indication that significant self-directed learning is required. Guidelines with regular updates may aid the learner in this

case as their reading list can be broken down and made available in organised smaller stages. Clear direction and instructions of how to navigate an online course is also essential as students may not be familiar with the organisation and can become frustrated if the course is difficult to follow.

Berge, (1998) highlighted a number of barriers to online education and introduced the term "faceless learning" giving the impression that personal contact is diminished or lost through online learning. However, others disagree reporting that communication is often heightened due to the various methods available for communication online Jolliffe *et al.* (2001). Users and instructors must be aware of the need to maintain effective communication to ensure they are benefiting from the tools available to them. It is important for students to interact with each other to increase their learning experience. Also, interaction between students and instructors is important for obtaining further guidance and also to give feedback on the course.

The extent of uptake of online learning is primarily the decision of the educator; they use their own knowledge to determine what is best for their course and their students. However, student needs are adapting to changes with technology and their demands for learning are changing to a more flexible approach. Therefore, the instructor not only needs to take the requirements of a course into consideration, but also those of the potential student.

1.5: E-learning and today's student

Traditionally, learning was controlled through the educator; i.e. the educator bestowed their knowledge of the subject onto a group of students. More recently it has been identified that there is a need for more responsive education (Young and Wilkinson, 2005), with students pursuing independence, flexibility and more accessible learning methods, which is gradually replacing controlled instruction (Ryan *et al.*, 2000; Ellaway, 2006).

Today, teacher-based learning is more frequently supplemented and increasingly replaced by student directed learning. This method individualises learning to the requirements of each student, where learners have control over their own personal educational interaction with regards to content, sequence, pace and timing. Although this method of teaching takes a flexible approach, there is an element of control. The learning environment is structured which aims to guide the student, rather than the educators giving continuous instruction (i.e. the student has controlled freedom).

When adopting online alternatives, traditional methods are not necessarily being replaced; it is the attitude to learning which is currently changing. Killian (1997) stated that the role of the educator is changing as is that of the student. *"Today's students are no longer the people our educational system was designed to teach"* (Prensky, 2001). Current and future students are more demanding and knowledgeable about alternatives for learning which increases their expectations (Berge, 1998). Students today also "*represent the first generation to grow up with this new* (digital) *technology*" (Prensky, 2001) ensuring that they are digital natives of the technology.

Videogames, the internet and other digital technologies play an integral part of life for today's children and young adults. It could be considered that digital natives (students) are native speakers of the digital language, and the digital immigrants (instructors) have had the harder task of learning to communicate in a new language in which they may become proficient but may not become fluent. Difficulties can arise as these digital natives are being taught by digital immigrants whose teaching style predates the virtual environment. This is a temporary situation which will ultimately be resolved with advancing time (Prensky, 2001). However, it is inevitable that today's native students will be destined to become the immigrants of the future. If technologies change as rapidly as they have in the past 20 years, similar problems may occur in the future.

A major problem when adopting online features is that the digital immigrant instructor is teaching via a medium where they have less experience than their (native) student. Instructors must utilise their knowledge of traditional teaching methods and combine it with training in digital technologies to ensure that the teaching of the future is predicated on the strengths of past pedagogy and not restricted by it. If instructors want to teach the future student, changes are inevitable due to the continuous advances in digital technology which will have a significant effect on learning and teaching in academic institutions. Communication with students will aid instructors to gain a perspective of what students want and expect from the use of certain technologies.

Although the digital immigrant must be aware of the needs of the digital native, the instructor must counterbalance that with the mature student who is also likely to be a digital immigrant who may require more guidance and flexibility. The "grey" or retires student is also becoming more common to the virtual university. These

individuals are seeking new activities in subjects of their own interest and they have the time and money to invest into online activities and although they are digital immigrants, their contribution to the university population is ever growing.

Universities must look into different strategies to maintain their student numbers and looking at opportunities for the "grey" student is a means of doing so. A range of technical abilities will be seen in students taking any course, therefore appropriate training is recommended when using any digital technology (Jolliffe *et al*., 2001).

1.6: E- learning in Practice

E-learning in Anatomy and Medicine

As discussed previously, an online search for a subject of interest with reference to online courses will generate a number of national and international e-learning courses in a particular subject area. These can be 100% online, a combination of online and face-to-face methods of teaching or an advertisement/application form for a traditional face-to-face course. Many online courses contribute to qualifications recognised and approved by the Scottish Qualifications Authority (SQA) and by the Secretary of State for Education and Skills for Learning and Skills Council (LSC) for the rest of the UK.

The search for "anatomy online courses" generated a number of available resources. These ranged from short free tutorials on one aspect of the human body (aimed as a review to students), to courses offered for a fee which contribute to qualifications recognised by commercial companies and academic institutions.

Innerbody (www.innerbody.com) is a free online resource which addresses each body system as a separate tutorial to teach the anatomy of the human body. A number of 2D images with interactive labels and further information links are used to teach each system. This online resource is an effective revision tool for students learning anatomy. Interactive labels are used to link between structures and give descriptions of form and function (Figure 1).

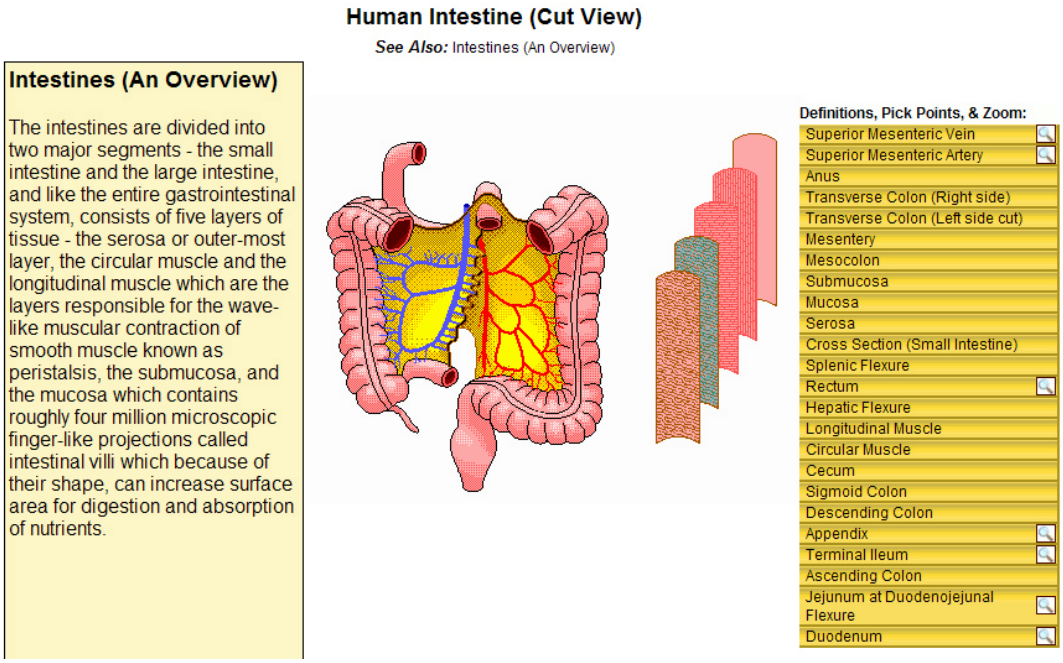

Figure 1: A webpage on the blood supply to the GI tract http://www.innerbody.com/image/dige08.html

One disadvantage of "Innerbody" is that it uses illustrations rather than images of real dissected specimens. This may not be problematic for revision purposes, however these illustrations do not convey a realistic appearance and illustrations are taken from averages, students may not understand the extent of variation found in the human body. Also, the images used cannot be resized for clarity and therefore some smaller aspects of many features may be difficult to understand. In some instances a link will take the student to a close up of a particular region, but the size and magnification cannot be manipulated for individual needs.

Navigation of each section is extremely complex as there are links to some features with descriptions but not others. There is no organised sequence in which features should be addressed which may result in some aspects being missed out. This flexibility however could be viewed as advantageous as students can navigate the website as they require, rather than being guided through the website.

Revision is the main goal of any anatomy website such as "Innerbody" discussed above. The immature "cartoons" throughout the entire website do not realistically convey the human body (Pers comm. Paterson, 2008). Paterson (level 4 undergraduate) reported the images in "Human Anatomy Online" (www.ect.downstate.edu/courseware/haonline/index.htm) to be more useful for revision as it uses images of real human dissection. This online dissector also allows users to zoom into images and uses links within the text to highlight key features. Although this dissector is useful for revision purposes, learning from it would be difficult and could never replace what you can learn from actual human dissection.

E-learn Canada (www.elearnca.com) is a distance learning college which offers recognised qualifications in anatomy and physiology. Following completion of the (recommended) 170 hour course, students are given two qualifications; an Anatomy and Physiology diploma issued by Stonebridge Associated Colleges, and an ASET level 3 anatomy and physiology award (recognised as an advanced higher grade in Scotland and as an A level in the rest of the UK). This 17 week program has been broken down into modules on each body system including pathological disease and histology. Learning outcomes are available to the general public however; there is no demonstration available to comment on layout or presentation of the course. Where "Innerbody" and "Human Anatomy Online" were

suggested to be good revision tools, this course is aimed at students with either no knowledge of anatomy who are seeking to gain qualifications, or professionals looking to improve their skills. The fee for this course is $575CAD (approximately £290) and does not require any previous qualifications. The course provides e-mail, fax and telephone access to a specialist to communicate any issues regarding the course and for guidance throughout the course.

E-learn Canada offers a number of home study and distance learning courses which all utilise online resources. A similar institution is the Open University which currently has over 180,000 students interacting online. This University is dedicated to distance learning and since the introduction of web-based materials to many of its courses it has been recognised as a world leading institution for e-learning. In the current digital climate this has served to increase student and course numbers in addition to creating collaboration opportunities for institutions and organisations both nationally and internationally. The Open University thrives on "supported open learning" where students learn at their own pace, in their own time with support from tutors and student services.

Medical education is currently adopting these views giving students more freedom to their learning whilst giving them guidelines and learning objectives. The internet is now being used as an information source for teaching medical education in addition to being a platform for supporting and delivering online learning programmes to medical students (McKimm *et al*., 2003). Medical education is an area of learning which relies on up to date, responsive education in the training of future healthcare professionals and is therefore continuously advancing by utilising available technologies (Young and Wilkinson, 2005).

E-learning technologies are being developed and introduced in a number of institutions who have blended e-learning with traditional face-to-face learning in a worldwide partnership. The International Virtual Medical School (IVIMEDS) was introduced in 2003 to take advantage of global medical expertise and, in conjunction with the benefits offered by internet access, create a standardised, yet flexible training curriculum for medical students.

High demands are being made with regards to a core-curriculum for the future of medical education (Harden and Hart, 2002). It is vital for the quality of training to be retained throughout institutions and improve student effectiveness using different learning media. Currently 31 institutions worldwide are members of IVIMEDS, which has grown and continues to grow due its success in harnessing and coupling the benefits of e-learning with technological advances. Collaboration is essential for medical schools to provide successful medical courses and if an international core curriculum is to be developed, IVIMEDS has provided a stepping stone for this venture.

IVIMEDS combines electronic learning resources and virtual reality with face-to-face learning (Sullivan, 2005). Digital elements available include reusable learning objects (RLO) in the form of interactive tutorials, virtual patients, guided learning modules and platforms which can be accessed through VLE software such as Blackboard™. Interactive tutorials can use animations to (for example) show the arterial supply to the head, neck and upper limbs (Figure 2). Sound recordings can also be included which can decrease the amount of text on screen, and may aid in engaging the learner.

Figure 2: Interactive tutorial of the blood supply to the head and neck (http://www.ivimeds.org)

These learning resources are made available to all participating institutions ensuring that they retain the ability to be reused. Each RLO can be adapted to fit the institution's curriculum as well as address individual student needs. E-learning in medical education has provided a link between frontline advances in both technology and medical education allowing out-dated procedures to be improved and modernised (Ruiz *et al*., 2006).

Harden and Hart, (2002) discuss how IVIMEDS aims to reform (rather than transform) medical education and this analogy should not be taken lightly. It is not the intention for textbooks and expert knowledge to be replaced by online alternatives, but for the use of technologies and e-learning to be utilised in higher education to supplement successful traditional teaching methods. The success of IVIMEDS (http://www.ivimeds.org/) has led to the creation of the International Virtual Nursing School (IVINURS) in 2005 and there are future plans for the International Virtual Dental School (IVIDENT).

Dr Stella Mitchell, Senior Lecturer in Anatomy and Dentistry was interviewed regarding the use of the VLE for medical and dentistry students at the University of Dundee. Mitchell reported that the dentists use the VLE to access lectures, timetables and discussion boards but in a very basic way compared to the medical school. The medical curriculum relies heavily on the VLE for its facilities in communication, education and administration. A curriculum map (C-map) has been created for students to have an organised curriculum with easy to follow guidelines. There is a calendar in which students can follow the days work but also link back to past work and forward to future work.

Clinical cases have been embedded within the curriculum for students of all levels to access which link to lectures, resources and activities they have either previously completed or will complete in future years. This indicates to students what they should know at their particular level and links to what they will learn in the future. For example when learning about the billiary tree in anatomy level 1, students are given links to other areas within the curriculum which mention clinical cases such as gall stones and jaundice which relate to this area of anatomy.

Instructors understand it is important to link their speciality with others in order for the student to fully understand the interconnectivity of their complex subject. Students have the ability to link back to anatomy lecture notes on the VLE is an effective tool, aiding students with diagnosis and treatment of clinical conditions. Although teaching facilities are available online, these are supplements to face-to-face teaching and in this case the internet does not replace these traditional methods, they are considered extra reading (Pers comm. Mitchell, 2008).

Despite the success of many e-learning programs, some individuals are reluctant to advance to this style of teaching. Professor Abboud from the University of Dundee's Department of Orthopaedics and Trauma Surgery was interviewed for his opinion regarding e-learning. Abboud currently offers four postgraduate paper-based distance learning courses teaching approximately eighty students per year. Prof. Abboud deemed the internet and technological support untrustworthy for the conversion of his courses into an online format. Due to common internet server crashes he stated the courses he offers will never be adapted for online delivery further than the application form (Pers comm. Abboud, 2008).

E-learning at the University of Dundee's College Of Life Sciences

The University of Dundee reports 100% module coverage on its VLE software (Pers comm. Parsons, 2008). Blackboard Learning System™ 8.0 is used within the university known as *"My Dundee"* (www.mydundee.ac.uk). Although not all lecturers have chosen to use *"My Dundee"* for delivering teaching material, students can access their individual modules for communication purposes (via discussion boards, emailing etc.) as student contact information is available for each module at the university.

In the College of Life Sciences (CLS) at the University of Dundee, undergraduate students are being introduced to online supplements to their teaching. In addition to face-to-face lectures, students also have online access to lecture notes (via Microsoft® Office PowerPoint), discussion boards, assessments, preparation tutorials, reading lists and many other materials. Prior to attending many practical classes in undergraduate level 1 and 2, students are expected to complete an online tutorial which prepares them for their lab. This method of teaching allows students who cannot attend or take part in the class

the opportunity to gain the practical knowledge of the subject. It also gives students attending the class the information and knowledge required for the class and their independent learning programme.

Many undergraduate level 1 and 2 modules in the CLS offer opportunities for self and peer assessment via an online drop box facility. Students submit assignments electronically through "*My Dundee*" and are given access to anonymous work to review. Assignments are graded and can be annotated for the author to view for feedback. Dr. Benwell, (Pers comm. 2008) a senior teaching fellow in CLS suggested that although *"My Dundee"* has many advantages an alternative to online materials must be retained. She reported that some individuals (students and instructors) do not like using online technology for learning and teaching and in some instances it is not appropriate to all modules or subjects.

Centre for Anatomy and Human Identification, CLS

The Centre for Anatomy and Human Identification (CAHID) within CLS offers the first undergraduate Bachelor of Science honours degree programme in Forensic Anthropology. This traditional face-to-face course utilises *"My Dundee"* for lecture notes (via Microsoft® Office PowerPoint), discussion boards, external links, module handbook, timetables and an electronic method for submitting assignments (via a drop box) but there are no teaching activities online. In the recent past, undergraduate forensic anthropology students were given access to a forensic anthropology society website which discussed current issues and current publications on the subject of forensic anthropology and human identification. However, this relied on student administration and was not continued after 2007.

The taught post graduate degree programs in Human Identification and Forensic and Medical Art use "*My Dundee*" in a similar way as the undergraduate course in Forensic Anthropology. Although "*My Dundee*" is not being used to its full potential, staff do not necessarily know the full extent of what "*My Dundee*" has to offer.

Dr Mallett (Lecturer in CAHID) received little training on the VLE. Through self training she was able to understand how to upload lecture notes, add links and respond to discussion boards. She suggests further training would be required to understand the full potential of *"My Dundee"*. Current courses available at CAHID are traditional face-to-face courses and although they may benefit from online activities, they do not necessarily require them at present. In the future, should the current courses be converted to distance learning courses, the Internet and "*My Dundee*" would be considered as a means of delivering the academic material but further training would be essential (Pers comm. Mallett 2008).

Although the Centre has not adopted internet resources to supplement teaching of the above courses, it has used a combination of e-learning and face-to-face training for police officers involved in the UK Disaster Victim Identification (DVI) team. This national training programme has solely utilised "*My Dundee*" for the theoretical component of their programme giving officers controlled access to an online course in the theory behind disaster management and human identification. Officers are only accepted onto the national DVI team when they have completed the online theoretical component of the course in addition to attendance at a week long practical training programme within the university.

Officers enrolled on the course have been chosen from police forces all over the UK and are registered as bona fide students, given

password access to the University's VLE and e-mail system to give officers access to the online aspect of the course. The DVI Programme Co-ordinator Lucina Hackman reported a number of firewall problems in the second year of implementation which occurred due to the strong firewalls in place in many police forces. Firewalls are put in place for security purposes to prevent encrypted data being accessed on a network. These are stronger in institutions requiring higher security (i.e. government offices, police forces etc), which caused problems on the DVI course when officers were accessing the course from their workplace. Opening e-mails, submitting assignments, taking assessments and accessing links were some of the problems faced due to firewalls. Problems were often resolved when officers used their home computers as the firewalls on personal computers are generally weaker.

These numerous problems required continuous attention from the DVI co-ordinator who could not have anticipated these problems as they were not experienced in the previous year of the training program. It can be suggested these problems were experienced in the second year due to updates on police firewall servers. Officers were advised to access the course from home to avoid these problems, however communication was often hindered. University e-mails, announcements on *"My Dundee"* and discussion boards were all used to contact officers on the course, however officers did not always respond to these and therefore personal e-mail contacts were utilised to avoid losing contact with officers. Fax and phone numbers were also made available to aid with the maintenance of the course pedagogy as some officers did not communicate via e-mails.

Communication on any online course is extremely important in order to retain contact with its students. Loss of contact could result in frustration both from the instructor and the student. It is therefore

important to offer a number of communication tools in order to reach students.

Although CAHID does not use the VLE to its full potential in all modules the current undergraduate and postgraduate courses do not necessarily require these at present. The DVI course is an excellent example of what the VLE can offer and therefore has been adopted for the method of delivering an online course for this project.

E-learning in Forensic Science

E-learning online is not subject specific as its diversity enables it to be explored and exploited in various subject areas. Many aspects relating to forensic science are currently being pursued by a number of institutions and organisations for the online training of forensic scientists (Staffordshire University, Oklahoma City University, and Coventry University to name but a few). Some online courses include compulsory short campus visits for lab work and exams, and others have used only the internet to deliver and assess courses.

The University of Florida has won awards for its contribution to distance learning in the field of forensic science. They offer a number of online courses which relate to either Master level degrees, certificates or non-credit courses. Environmental forensics, forensic toxicology and forensic death investigation are some of the courses offered online which follow similar patterns of organisation with respect to coursework. They are all conducted fully online, with the exception of the degree programs which require a three day campus visit to take the degree qualifying exam.

The Physicians for Human Rights organisation (http://physiciansforhumanrights.org/) provides a free online course in forensic investigation aimed at students new to the field of forensic

science who may not have had training resources available in their area. Content detail is vast, however interactivity is lost due to almost excessive amounts of text within each module. There are short self-evaluation quizzes available which consist mainly of multiple choice questions. This is the most interactive part of the course but does not create learning experiences essential for active, lifelong learning. Hyperlinks to journal and news articles, published papers and websites are scattered throughout the modules and a required reading list also forms part of the course. Reading large amounts of text is the basis of this course and although it provides a lot of relevant information, it does not attract different learning styles and it is the author's opinion that this style of teaching encourages passive learning.

Canyon College (www.canyoncollege.edu) in California, USA is the only known institution to provide an online course in forensic anthropology. The profile of this subject has grown in recent years due to forensic anthropological involvement in mass disaster investigations such as the attacks on the Twin Towers (2001) the Asian Tsunami (2004) and the London Bombings (2005). The need for forensic anthropologists is essential in cases such as those mentioned above and appropriate training of these professionals is crucial. In addition to this, the demand for courses in the subject of forensic science has been heightened by the so called "CSI" effect. Due to growing popularity of television programs such as CSI, Bones, Silent Witness etc, the demand for courses in the subject area has increased (Nation Master 2005).

The online course in forensic anthropology offered at Canyon College has no prerequisite training required for applicants. The course is delivered entirely online and does not require any exams to be taken on campus. The course is primarily based on a textbook (*Flesh and*

Bone, an Introduction to Forensic Anthropology, by Myriam Nafte) and also utilises online communication applications such as e-mail and discussion boards. Assessment is entirely online but few are given. Age progression and facial reconstruction labs are available; however they rely on demand and a sufficient number of students registered to be able to be accessed.

This 8 week course costs $500 and gives "graduates" qualifications towards a Bachelor of Science in Applied Police Science. Degree programs from Canyon College are recognised by the Association for Innovation in Distance Education (AIDE), which, in the case of the Bachelor of Applied Police Science, will aid individuals pursuing employment in the police force, or those seeking to further their education in criminology, forensic science or law.

To obtain this degree, students must complete 3 foundation courses, 10 core courses and 5 out of 7 electives. The discussed forensic anthropology course forms one of the core courses along with crime mapping, crime scene investigation, death investigation and terrorism threat (to name a few). From the list of core subjects this degree does not necessarily train the forensic anthropologist but provides basic knowledge on the subject relating to police science. This knowledge would aid in those pursuing a career in the police force, giving them information about who they may work with and their role they play in an investigation. From an academic point of view, this degree would give a foundation qualification to those wishing to follow forensic anthropology further.

This course is cost effective, compared to traditional on campus courses with respect to living costs and university fees. However the course suggests it is an introduction into the subject of forensic anthropology and further training would be required for those

pursuing this as a career. There is no reading list and the entire course is based on one text book. Further research into other courses offered by Canyon College indicates each course is based on one text book, which does not necessarily give the student variety or depth in their learning.

As this course is the only one of its kind, focussing solely on forensic anthropology, it can be suggested the subject could be approached by other more effective mechanisms online.

1.7: Considerations for creation, management and evaluation of online teaching material.

Expert knowledge of a particular subject does not necessarily coincide with the ability to input or convert the knowledge into efficient online learning material (Good, 2002). Material which works well in one form may not necessarily be as easily and effectively transformed into a format capable of online delivery. Instructors not only need background knowledge of a subject and expertise of traditional learning, but must understand how to make the content applicable for online delivery. Content is a major portion of learning, as without it, there is nothing to learn. However, knowing how to implement and convert the content into a complete, useable, integrated online experience, taking advantage of a variety of resources and activities, is key to effective online delivery (Shaw, 2002).

The majority of previous research into online delivery of higher education material consists of anecdotal observations and personal summaries of teaching experiences (Owston, 2000; Monteith and Smith, 2001). Although important, the internet may not be suitable to every course considering an alternative delivery, due to external influences including the creators, students and instructors. The

following guidelines are suggested by Savenyee *et al.* (2001) for consideration prior to the formation of an online course and shall be discussed in general and with regards to implementing an online course in skeletal development. This are of forensic anthropology is important to address online for its suitability as it would give users worldwide access to resources which are not readily available.

- Need for the course
- Perceived appropriateness of the course for online delivery
- Learners' attitudes and expectations
- Pedagogical concerns
- Resources available

- **Need for the course**

Courses in high demand world wide are more commonly being considered for online delivery (Savenye *et al.*,. 2001). If there are students willing to undertake the course, there is a need for the course whether they choose to work online or attend a course on campus.

Currently over 400 students per annum apply for the University of Dundee's undergraduate course in Forensic Anthropology. Approximately 30 students are offered places and 25 students are enrolled. The high demand for the existing on-campus course deems the course potentially suitable for an online alternative to meet student demand. Also, the development of the skeleton has not yet been addressed in an online format and the University of Dundee is in a prime position to capitalise on a leader status position due to the expertise associated with CAHID and the available teaching resource, i.e. the Scheuer Collection (discussed Chapter 2).

- **Appropriateness for online delivery**

The appropriateness for online delivery must be addressed when considering alternatives to traditional learning and teaching. All courses require some form of redesigning for effective conversion into an online format and therefore a course can be considered whether it is bespoke or already extant.

An important element to discuss when considering an existing course is whether the present content is adaptable to online delivery. Materials based on text can generally be converted to an online model as can quizzes, discussion questions and imaging. However, practical elements such as lab work may cause difficulties when considering adaptation.

This project aims to address the question of whether forensic anthropology, and more specifically, the development of the skeleton, is suitable for a multimedia approach to online delivery. The text content of the course will be readily transferable to an online format and will have the ability to include interactive elements such as word highlights and sound. However, the practical aspect of the course will require 3D digital images of juvenile remains and this may be more complex to teach. A major question to be addressed in the project is:

"Can we learn as much from 3D digital images as we can from handling the real specimen?"

More and more research in forensic anthropology relies on evaluation from images. The subject is becoming virtual, largely driven by lack of access to real material; however learning from images must be understood (Rutty, 2009). Images must be interpretated accordingly for effective use whether in a forensic case or in a teaching environment.

Brown and Herbranson is an imaging company which has designed various 3D facilities used for teaching human anatomy and osteology (www.ehuman.com). Their latest work has involved the production of a virtual human dissection manual (E-human) which allows the user to dissect online. Other products from this company include a 3D tooth atlas and a 3D skull atlas. These are accessible online for a specific amount of time following a monthly fee of $49.99 after a registration fee of $499.00. From the demonstration online it seems to be a useful tool which breaks down the complex topic of human anatomy into simple understandable components. They have documented the 3D skull atlas to being *"dramatically better than having a skull in one's hand"* due to the ability to build the skull bone by bone. Each bone has the ability to be turned on and off revealing underlying structures near impossible to achieve in human dissection.

This project will address the appropriateness for online delivery of a course in the developing "hip" bone (innominate) by testing the content on students and staff within CAHID. Evaluation will be key to answering the question above as it will give personal views on the test module which will be created to deliver the teaching material. Assessment scores will also be taken before and after the teaching material is made available to users to test progressive learning.

- **Learners' attitudes and expectations**

Online learning requires active learners who take control of their own learning; they can no longer be passive note takers in a lecture situation. Their needs as a collective group as well as individuals must be considered in addition to their level of motivation.

Motivation is a major weakness in independent learning, self responsibilities are higher and students must have confidence in working in a virtual environment. Although freedom is a major

advantage to online teaching, too much may create insecurities amongst learners and frustration levels are raised (Shaw, 2002). However, leaving the material open ended, where the learner has guidance in addition to freedom, has been reported to provide richer learning experiences (Shaw, 2002). Instructors may need to re-think what motivates their student, and how they can implement this into a new way of learning (by student control). Aims should be set both by the student and the course (by learning outcomes) to guide students to their requirements and goals of the course.

At the University of Dundee, a number of online facilities have been made available to Life Science students who have generally given positive feedback to the online elements of their course (Pers comm. Benwell, 2008). This project aims to acquire and analyse student feedback on the test module to address their attitudes and expectations towards the internet as a tool for learning.

- **Pedagogical concerns**

Teaching strategies must be adapted to allow effective transition from traditional learning to e-learning. "*Pedagogy is now no longer solely about designing distant activities but also about designing virtual and immediate ones*" (Good, 2002). Concerns regarding the adaptation to the use of the internet in teaching can be raised by instructors, institutions and students.

Initially it is the instructor who must be willing to learn new technologies in order to create and deliver a course online. Brooks, (1997) stated that if there is access to the World Wide Web, there is the ability to create a website. There are numerous courses available online that teach basic and advanced skills in a variety of disciplines, including that of web and online course design. However,

"WYSIWYG" features available on VLE platforms (such as Blackboard™) do not require any significant or formal prior training.

The profile of learning and teaching is changing significantly with the input of the internet and it is important that this is addressed by instructors. Technical staff and student input can be highly beneficial for instructors as they gain technical advice to create their course in addition to receiving opinions from students to improve their course. Instructors and students often require moderate training in computer skills and technology, and need confidence to enable effective learning. Appropriate support is also necessary to avoid "*aimless surfing*" within a course for students to gain the knowledge essential for understanding whilst effectively avoiding internet distractions, (McKimm *et al.*, 2003). Concerns regarding the creation of the proposed online course will be addressed by utilising the technical staff within The Learning Centre for their expertise on the creation and implementation of e-learning activities.

Student concerns of this method of teaching can be as simple as commenting on the layout. O'Leary and Ramsden (2002) discuss that the features of a VLE must have a consistent, customised look to allow students to develop familiarity with the tools which in turn will enable easier navigation and build confidence and comfort with the task set. The layout of a course is also important as students may need all the information for a particular subject available at once. Also, breaking a subject down into smaller "bites" with requirements and learning outcomes will allow information to be addressed in smaller parts without overwhelming the student with vast amounts of information.

Students and staff assessing the proposed test module will be given objectives for each aspect of the course to give them a clear

indication of what they should be learning. They will also be given instructions via email and within the course (via announcements) for activities they must complete.

In order to overcome any concerns, evaluations can be introduced. Undertaking evaluation of a course is important to the instructor, institution and the student. Knowing student opinion can guide instructors to develop changes that benefit the student and the course. Creating the course will improve the instructors' ability to work with technologies giving them flexibility for other courses in which they may be involved. For the institution, evaluations can lead to improving the quality of teaching and highlight the institution as benefiting from these new technologies in learning and teaching. This may prove to be an effective marketing tool to attract the digitally native student as it increases the feeling of engagement.

When implementing online materials into a teaching package they must be analysed to ensure they meet appropriate standards for the institution. A successful online course will be dependant on a number of factors including the quality of its instructional design, available support from academic and technology staff, the quality of teaching and the course content, and its ability to engage and motivate students (Wright: accessed 2008). Sonwalkar (2001) devised a statistical method of evaluation which uses a rating formula and incorporates scores from pedagogical and delivery techniques which can be used to compare online courses. However, this method has not been utilised by any institution undertaking an evaluation of their own online course and in the author's opinion cannot be effective between subject areas.

Evaluation of a course aims to test the quality of learning and gain feedback from users of a particular course in order to improve the

course. Comparing online courses between subject areas is not necessarily useful to an instructor as they want information about their course and ideas of ways to improve it. Addressing a number of elements (such as interactivity, technologies available, communication and content) is useful using a template evaluation such as Sonwalker (2001), however addressing user opinion and reporting individual experiences will directly provide constructive feedback which can lead to continuous improvements of a particular course.

Wright looked at accessibility, organisation, language, layout, goals and objectives, course content, learning strategies and learning resources as criteria to evaluate an online course. This anecdotal interviewing method for evaluation is widely considered for individual evaluation of a particular course however, it is highly biased and does not provide any scientific benchmarks for assessing the quality and appropriateness of a course (Urquhart *et al.*, 2004; Conrad, 2004, Ellaway *et al.*, 2004). Urquhart used a face-to-face interview method to evaluate the use of VLEs, asking questions such as; "How do students view learning with VLEs?" Although highly considered, difficulties arise here as interviewees are not given a range of answers and therefore, individual opinion can be gathered but no statistical analysis can be undertaken. Interviews are personal and unique to the particular interview therefore, with the exception of using similar questions in an interview, it is not particularly useful to base and compare an evaluation of one course to an evaluation of a course based on a different subject.

Evaluation methods have also consisted of checklists, determining whether specific features are available (Ellaway *et al.,* 2004), deeming them more effective and efficient the more tools that are available. However, not all tools are necessary or indeed applicable

or useful to all online courses and therefore evaluation may not be effective if undertaken by comparing resources to a checklist.

Kirkpatrick (1959) devised a method for evaluating training systems in a commercial environment. Some online instructors have applied and adapted his methods to their research when evaluating their online course (Kaufman and Keller, 1994; Alliger and Janak, 2006; Bates, 2004). Bates (2004) reports this to have its advantages looking at reaction, learning, behaviour and results but also documents that individual influences are not addressed in this method.

Feedback forms such as those used by IVIMEDS (Appendices 1 and 2) provide a number of possible choices for students to answer each question. Answers can then be compared between students to give feedback on a particular aspect of a course. IVIMEDs have used a number of methods in the evaluation of their course (Pers comm. Lafferty, 2008). A mixture of student feedback forms, interviews, focus groups and assessment scores are used by IVIMEDs for evaluation purposes. An evaluation form (Appendix 1) and a student survey (Appendix 2) show the questions asking for the students' opinion of the learning material and their relevant experiences. Comparison of assessment scores from students involved in the online material and students without access to the material is also possible for evaluation purposes.

CLS at the University of Dundee creates optional evaluation forms for all their undergraduate and postgraduate modules which are taken and submitted online. These give an overview of the entire course with specific questions regarding the online aspects of the course including communication with instructors. Student feedback is important for the future improvements of all aspects of any course in

the college from an educational, administrative and communicational point of view. Although participation is optional, CLS enjoys a high student participation rate for evaluation forms (Pers comm. Benwell, 2008).

Although evaluation is an essential component to the creation and continuous monitoring of an online course, there is no consistent method by which this may be achieved. Due to limited statistical research regarding evaluation methods, anecdotal methods seem to be the preferred approach adopted when evaluating a course. It is the author's opinion that each course is unique and suitable evaluation of a course should be individual to each, a universal evaluation form would not be beneficial as instructors will want to achieve different outcomes from their evaluation. An interview technique is extremely personal and provides insight into what a user's thoughts and views are about a course, but will not provide any statistical results. This in turn will make it difficult to compare courses, but it is not necessarily relevant to compare courses outwith the same subject area.

Evaluation of the test will be undertaken via online feedback forms in this project and in some instances, face-to-face interview will be conducted to understand the learner's views of the online module. These will include questions which will ask users to comment on what they thought of the course in addition to questions with a number of options as answers. In addition to this, assessment scores (discussed above) will be taken to test how much users have learned. This will provide both qualitative (from evaluations) and quantitative (from assessment scores) data to assess the suitability of e-learning in this subject.

- **Resources available**

Due to online courses being accessible from any computer connected to the internet, they must have all the appropriate technical resources required to run the course without becoming a financial burden to students. Specific software required for a course should be limited to what is available to users at no additional cost. Effective use of the available tools online is important; poor access or slow uploading materials will hinder the learning experience and this can be addressed during the creation process (McKimm *et al.*, 2003). Technological staff should be approached for the plan, design and delivery of the course if the instructor is unsure. Also, technology should not be implemented just because it is available, the appropriateness for any technology which may be used should be evaluated with regard to the needs of the particular course in advance of implementation (McKimm *et al.*, 2003).

VLE software is currently operated by the University of Dundee ("*My Dundee*"). The creation of an online module would utilise the tools within "*My Dundee*" to create an effective, efficient learning tool. There is also a technical e-learning team (The Learning Centre) within the University who are dedicated to the development and support of e-learning activities within the University of Dundee. "*My Dundee*" will be utilised for this project, and The Learning Centre will be consulted for the implementation of an online module. Students and staff evaluating the test module will be familiar with "*My Dundee*" therefore training in using the platform will not be necessary, but will be considered if the project is to be implemented in the future.

In addition to having the available resources and aid for implementing a course online, CAHID houses a unique teaching resource which may be suitable for online delivery. The Scheuer Collection is an irreplaceable collection of juvenile skeletal remains

currently used for teaching the development of the skeleton during the traditional face-to-face undergraduate Bachelor of Science degree in Forensic Anthropology. Online dissemination of material from the Scheuer Collection will aid in the long term preservation of the fragile remains whilst creating wider access to the unique material.

The expertise and resources available at CAHID make it an exceptional candidate for the creation of an online course in skeletal development. Before online alternatives can be put in place as a teaching alternative (or supplement), they must be tested (O'Leary and Ramsden, 2002). They suggest that instructors should test any online activities on colleagues within their department before releasing them to students. However, this does not take into consideration the views of students; therefore it is proposed that both staff and students within CAHID will test the suitability of teaching the development of the skeleton online.

This project will consider only one aspect of the skeleton and its development initially to assess and evaluate the effectiveness of the conversion to online teaching. The development of the innominate shall be addressed initially (in this project) and its success may result in the development of a course based on the development of the entire skeleton. The use of activities such as interactive text, sound, 2D images and 3D animations will be utilised to attract a number of learning styles. Links to journal articles and websites will also be included for further reading. A virtual format using scans of elements of the Scheuer Collection would also begin the process of preserving the skeletal material.

1.8: Aim and Significance

Aim

This pilot research aims to assess and evaluate the suitability of e-learning as a means of dissemination of academic material for the teaching of forensic anthropology, and more specifically developmental juvenile osteology.

Significance

This Master's of Science by research is a one year project that aims to address the preliminary stage of a potentially larger project to discuss and develop an online, multi-institutional degree in forensic anthropology. The current project will assess the suitability of e-learning as a medium for the dissemination of academic material prior to the development of a full virtual degree in forensic anthropology. At the University of Dundee one of our areas of particular expertise lies within the field of juvenile skeletal development and this project will focus on creating a teaching package on the development of a specific region of the immature skeleton. The development of the innominate will initially be addressed with the intention of continuing with the remaining skeleton if the project proves successful.

Introduction of this course not only intends to explore the extensive teaching environment of the web to enable students to partake in an online interactive course, but also aims to preserve resources held at the University.

Introducing a teaching package online may be best addressed by the digitally native creator, who in this case has knowledge of what the

internet and available technologies are capable of providing in addition to knowing what attracts students to the internet and teaching. The more traditional expert (digital immigrant) whose knowledge of the internet has been learned, rather than taught from a young age, can monitor the creator using their expertise in traditional pedagogy and the subject matter to ensure maintenance of academic standards. This will enable a more efficient, effective way of teaching online whilst retaining the knowledge and academic standards required in a particular subject.

In the future, should this prove successful, there is the potential to cover a wider range of subjects within forensic science and create an equivalent to IVIMEDS in the subject of forensic science (International Virtual Forensic Science - IVIFOR). Similar to IVIMEDS, IVIFOR could be a worldwide partnership for teaching forensic science subjects utilising worldwide expertise.

Chapter 2.

Materials

The Scheuer Collection

The Scheuer Collection represents over 125 individuals aged between 18 weeks *in utero* and late adolescence, some of which have their age at death, cause of death and sex documented. The material is invaluable for education and research into skeletal development as resources of this kind are not readily available. In the UK, as a consequence of the Alderhey scandal (1984-1999,) the amount of fetal and infantile material held by anatomy departments has been significantly reduced, which inevitably adds to the uniqueness, and irreplaceable nature of the Scheuer collection.

The juvenile material has been collected by Professors Louise Scheuer and Sue Black, principally from various UK anatomy departments in addition to archaeological sources. Their expertise and knowledge gained from the collection, led to the creation of three textbooks which focus solely on the development of the skeleton; "*Developmental Juvenile Osteology*" in 2000 "*The Juvenile Skeleton*" in 2004 and *"Juvenile Osteology: A Laboratory and Field Manual"* in 2008. This has in turn led to the foundation of a module in juvenile skeletal development which forms part of the UK's first undergraduate degree programme in Forensic Anthropology.

In 2006 the Mathew Trust provided a grant to facilitate refurbishment of a reserved area within the Centre for storage of the collection (Figure 3 and 4). The funding also supported full conservation and curation activities to ensure the long term survival prospects of the material.

Figure 3: The secure environment where the remains are stored.

Figure 4: The remains are individually boxed, labelled and stored.

Information about each specimen has been entered into an electronic filing system to allow researchers to search through a record of the remains before handling them. This is an important preservation concept due to their fragile and irreplaceable nature.

The increasing number of students handling these remains deems them susceptible to damage, (Caffell *et al*, 2001) and they are therefore in need of appropriate protection. Following ten undergraduate practical classes in 2008 where elements of the Scheuer Collection were used, 4.5g of dust from the bones was collected. If this continues in the future, the remains may become highly damaged and may have to be withdrawn from teaching. Although handling the remains may be the best way to learn from them, a dilemma is created due to the fragility and need to preserve the remains.

It is feasible that the repatriation of these remains may become an issue at some time, resulting in the loss of the collection via directions for reburial or disposal. Currently there are legal restrictions that govern the retention of human remains in Anatomy Departments. The Scheuer Collection has been licensed to be stored in the University of Dundee following an inspection by HM Inspector of Anatomy J.S. Metters in 2006 who stated that he was "*satisfied that the skeletons and bones in the Scheuer Collection were lawfully held under the 1832 Anatomy Act*" (Appendix 3). However, the need for safeguarding this resource is crucial as the law may change which has the potential to demand the repatriation of these remains.

The Native American Graves Protection and Repatriation Act (1990) exists to "*provide protection of Native American graves*" therefore any remains suspected to be Native American have the potential to be sent back for appropriate repatriation (NAGPRA www.nps.gov).

J.S Metters confirmed upon inspection of the Scheuer Collection that there was "*nothing to suggest that any of these remains were from ethnic communities, in particular from those community who have asked for return of skeletal remains that were brought to Great Britain for anthropological research*." However, in the future, if the collection is deemed inappropriate for education and research (through legislation or public opinion) then the inspector's stance and the legislation may change resulting in the repatriation of the remains.

This issue can partly be addressed by digitising the remains within the Scheuer collection creating a digital archive. Therefore in addition to preserving the material and increasing access, there will always be an electronic version of the remains if the bones are requested to be returned for repatriation / burial / disposal.

Following digitisation of the Scheuer Collection, the potential for online activities for teaching the development of the skeleton is heightened. It is proposed that equivalents (or supplements) using e-learning activities and digital versions of the remains in the Scheuer Collection could be explored to test the suitability as an alternative (or addition) to teaching. The introduction of an online course of juvenile skeletal development would explore the extensive teaching environment of the web enabling students to partake in an online interactive course on the juvenile skeleton.

In this instance, a number of JPEGs and four 3D models of innominates in the Scheuer Collection will be developed in order to highlight different stages of the maturation of the innominate. The 3D virtual models (Figure 5) include; a perinate (catalogue number - SAD) to highlight the characteristic features of the pelvic elements at the time of birth, a 6 year old (catalogue number - P9) to highlight

the first area of fusion between the three bones of the innominate, a 15 year old (catalogue number - A11) to highlight the changes seen in the maturing innominate and an adult pelvic girdle was included to convey the full spectrum of its ontogenetic development.

Figure 5 - Four specimens utilised for conversion into 3D virtual models.

In addition to testing the suitability of e-learning in the subject of skeletal development, this research aims to assess whether students can learn from 3D digital models of these remains as well as they would by learning from the real specimens.

The data collected from these scans could also be used to create 3D plaster-based casts which could potentially be used for future teaching within the Centre to avoid personal handling of the collection. These, 3D virtual models may also form the baseline for conversion to plaster based replicas of the unique material making it available for wider traditional teaching purposes.

This approach has been tested on part of a perinatal sphenoid bone (Figure 6 A). Hyperfocal, laser scanned the bone and the replica was cast in resin. The replica was then painted to convey the real-life appearance (Figure 6 B). The texture and weight of replica almost mirrors that of the original.

A B

Figure 6 - Actual perinatal sphenoid (A) replica (B)

In addition to aiding the undergraduate degree programme at the University, digitising the Scheuer Collection using 3D digital models will allow dissemination of the image archive on a wider scale. This could potentially heighten collaborative work with other academic institutions as the virtual Collection would be available (upon request). In order to test the suitability of the digital Scheuer Collection the innominates discussed above will be converted into a 3D digital format using a 3D surface laser scanner in addition to several software programs.

Chapter 3.

Method and Discussion of Methods

The data gathered for the purpose of this project was collected from students and staff enrolled on a test module (Developmental Osteology) made available on the University of Dundee's VLE; *"My Dundee" (*https://my.dundee.ac.uk). The test module was created on *"My Dundee"* to provide an online environment for the secure delivery of academic material in the subject of forensic anthropology. Only the users registered on the module had access to the material and they included 13 staff, 119 undergraduates and 21 postgraduates within the Centre for Anatomy and Human Identification (not all of whom completed the module).

The test module will addresses the development of the innominate bone which will utilise images, text, external links and journal articles for effective online teaching. In addition to 2D images, the module will include 3D virtual models to test whether participants can learn the development of the skeleton through interactive 3D models in the same way they would via direct inspection of the actual specimen.

This chapter has been divided into four sections:

- **3.1: Equipment and discussion of the equipment used for digitising the bones used for the project**
- **3.2: Creation of the online module "Developmental Osteology" - Method and discussion**
- **3.3: Participants; procedure and timeline**
- **3.4: Analysis of data**

3.1: Equipment and discussion of the equipment used for digitising the bones used for the project

- NextEngine™ desktop scanner and ScanStudio Core™
- Autodesk®MAYA®
- Adobe®Flash®
- Adobe®Photoshop® CS3

NextEngine™ Scanner

The NextEngine™ 3D desktop scanner was used to create 3D digital models of the four skeletal specimens discussed previously. NextEngine™ created a 3D desktop scanner which has the ability to capture 3D objects with multi-laser precision whilst retaining the outer texture of an object. The scanner works on a turn-table mechanism which captures both the 3D object (with lasers) and the surface texture using 2D digital images (via a built in digital camera) at a resolution of 3 megapixels. The digital images are linked to the surface scan and are mapped onto the surface geometry of the virtual bone. This enables the texture and the outer detail to be retained. The alignment of the underlying geometry and the surface is stored in an *ad hoc* file format (SCN) which can be used only in the given software made available upon purchase of the scanner; ScanStudio Core™. This software is used to set up each scan and the resulting SCN files are used within the software for the alignment, editing and fusion of an object (each will be discussed further). The complete model can then be saved and exported in a number of different file formats (for example; OBJ and STL) to be used in 3D modelling software such as Autodesk® MAYA®.

Scanning and set up

The scanner remains stationary and the object is mounted onto a turntable which communicates with the scanner via a cable and rotates in order to allow the scanner to capture the entire surface of an object. Initially the bones are placed on the turntable and secured in place by an attachment placed above the object (Figure 7).

Figure 7: Scanner linked to the turntable, set up to scan the innominate.

Using the ScanStudio Core™ software the scan settings are adjusted to the appropriate needs of each object. The settings are adjusted on the settings screen (Figure 8) which contains options to take into consideration the size, brightness, and smoothness of each object.

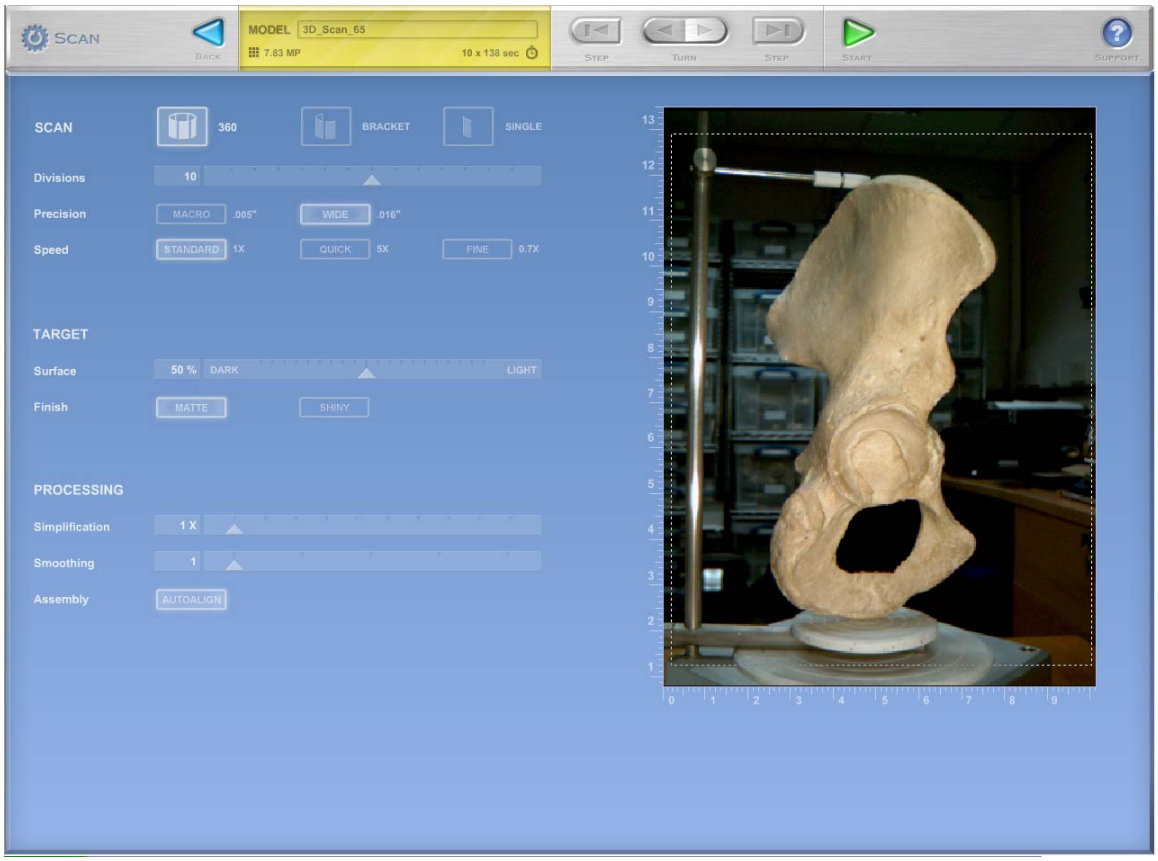

Figure 8: The settings page on ScanStudio Core™.

The innominate above has been set to scan 360°, it has been separated into 4 divisions and set at the standard speed for a "wide" object. The object to be scanned is 50% dark and 50% light and is matte in colour (opposed to shiny). The processing settings have been set not to simplify or smooth the resulting image in order to capture maximum detail. Also, the assembly of the scans has been set to align automatically. The white dotted line around the image of the bone is the selected region in which the scanner will capture the object. These processes will be discussed further.

SCAN (rotation, division, precision and speed)

There are three options for the rotation of the turntable; 360, single and bracket.

The 360 option rotates the scanner 360° on a vertical axis and takes scans at each division. The number of divisions is stated below the rotation option on the setting screen and allows the user to split the rotation into a desired number of scans. For example if the rotation is divided into 10 divisions, the 360 option will rotate the object 360° and stop to scan at 10 equal stages (Figure 9). Together these scans will create the 3D virtual scan family. The greater the number of divisions of a rotation, the greater amount of surface will be captured.

Figure 9: Scan family (10 divisions in total, 7 visible).

Single scans require no rotation and are used to capture one view of the object. These may be used to fill areas which may be missed on previous 360 families or to capture a particular area in finer detail.

A bracket option is also available where the scanner scans three consecutive divisions using partial rotation of the object. This option is also used to capture missed areas and add finer detail.

The precision option (Figure 8) corresponds to the size of the object and the distance required between the turntable and the scanner to

capture the entire object. The turntable is connected to the scanner by a cable which has two lengths dependant on the size of the object. When scanning small objects, the cable is placed at the shortest length ("macro") and the corresponding option is selected on the setting screen. Larger objects are placed on the turntable at the "wide" distance on the cable and the setting screen. Selecting "macro" or "wide" enables the scanner to adjust its field of view to the relative size of the object.

The speed of the rotation corresponds to the detail captured in the scan. Three options are available; standard (1x), quick (5x) and fine (0.7x). Options are chosen dependant on the complexity of the object.

TARGET

The target section allows the user to input details about the surface of the object to enable the scanner to take into consideration certain features of the object prior to scanning. These features include the brightness of the object, represented as a percentage of light vs. dark, and whether the surface of the object has a shiny or matte finish. The target section is available to improve the quality of the resulting scan(s).

PROCESSING

The processing application allows the user to make decisions about the outcome of the scan regarding its resulting simplicity and smoothness. The more simple the object is made on the scale between 1 and 5, the less detail conveyed in the surface of the resulting scan. Also, the more simplistic the object the smaller the resulting file size. File size is important as files which are too large may cause problems when exporting the files into other software programs such as slow uploading and slow running. However, a

smaller file size may not necessarily retain the amount of information necessary to convey the object effectively.

The smoothness option works in a similar way where the smoother the object outcome, the less detail is contained in the underlying geometry and the smaller the file size. The assembly option can be chosen for the scan family to align automatically or manually (discussed page 8).

The adult innominate bone above has been scanned using the settings discussed in Figure 8 can be seen below in the editing screen of ScanStudio Core™ (Figure 10). The green section above shows the individual divisions of one 360° rotation. The main image shows the divisions (in green) which have been automatically aligned to create a 3D scan family. In the editing screen below, the toolbar provides further applications for editing the scan families including; alignment, fusion, and simplification (each discussed below).

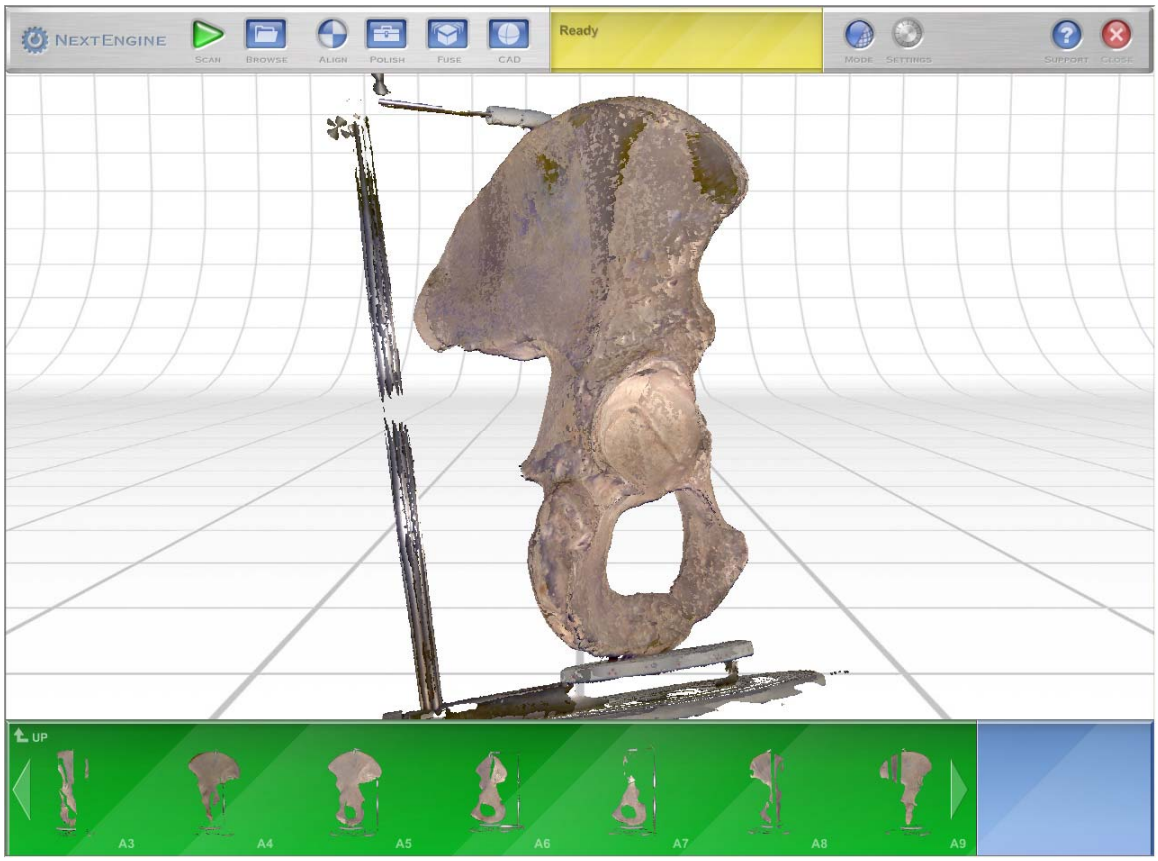

Figure 10: Scan family seen on editing screen

The tool bar at the top of the screenshot above (Figure 10) provides a number of features including alignment, polish and fuse which can be applied when editing the scan family.

ALIGNMENT

An automatic alignment feature takes each consecutive scan and attaches it to the next, creating a scan family. However, complex objects may need to be manually aligned if the object appears misaligned or if the software does not recognise the object as complete (Figure 11). Congruent features are manually located on consecutive scans and matched using pairs of coloured pins (circled), to triangulate an accurate alignment. Two single divisions are used (one in the green section A1 and one in the blue section A10) to align to each other and the software intelligently aligns the remaining scans.

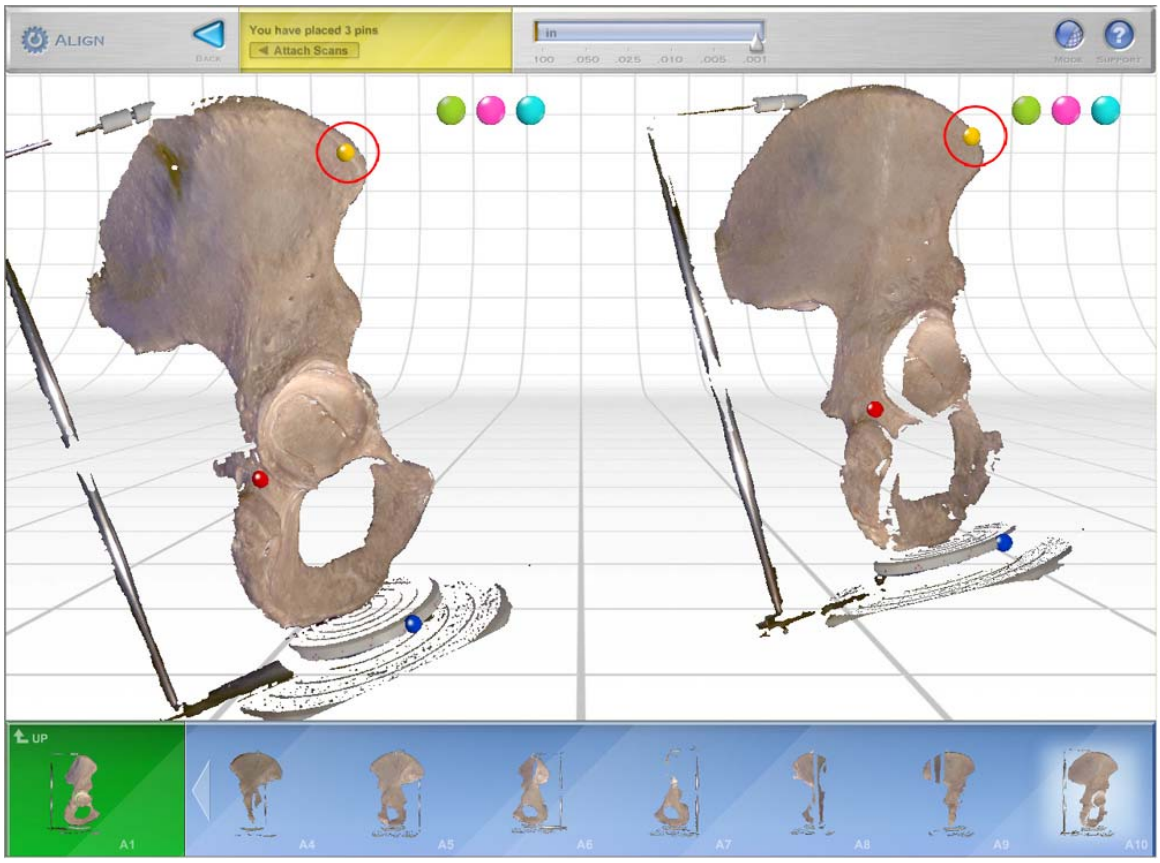

Figure 11: The manual alignment process

POLISH

Following alignment of the scans, editing features are available in the polish application. This editing feature allows the user to erase unwanted artefacts (such as the turntable and stand) using the trim function (Figure 12), fill holes using the fill option, smooth surfaces using the buff tool (not used in this project) and reduce the file size using the simplify tool. Before any polish tools are used the software automatically saves a backup model file in case mistakes are made.

Trim - Foreign objects and unwanted shadows can be deleted from individual divisions or entire scan families using the trim tool (Figure 12). The red highlighted area above indicates the part of the object which will be erased using the trim tool.

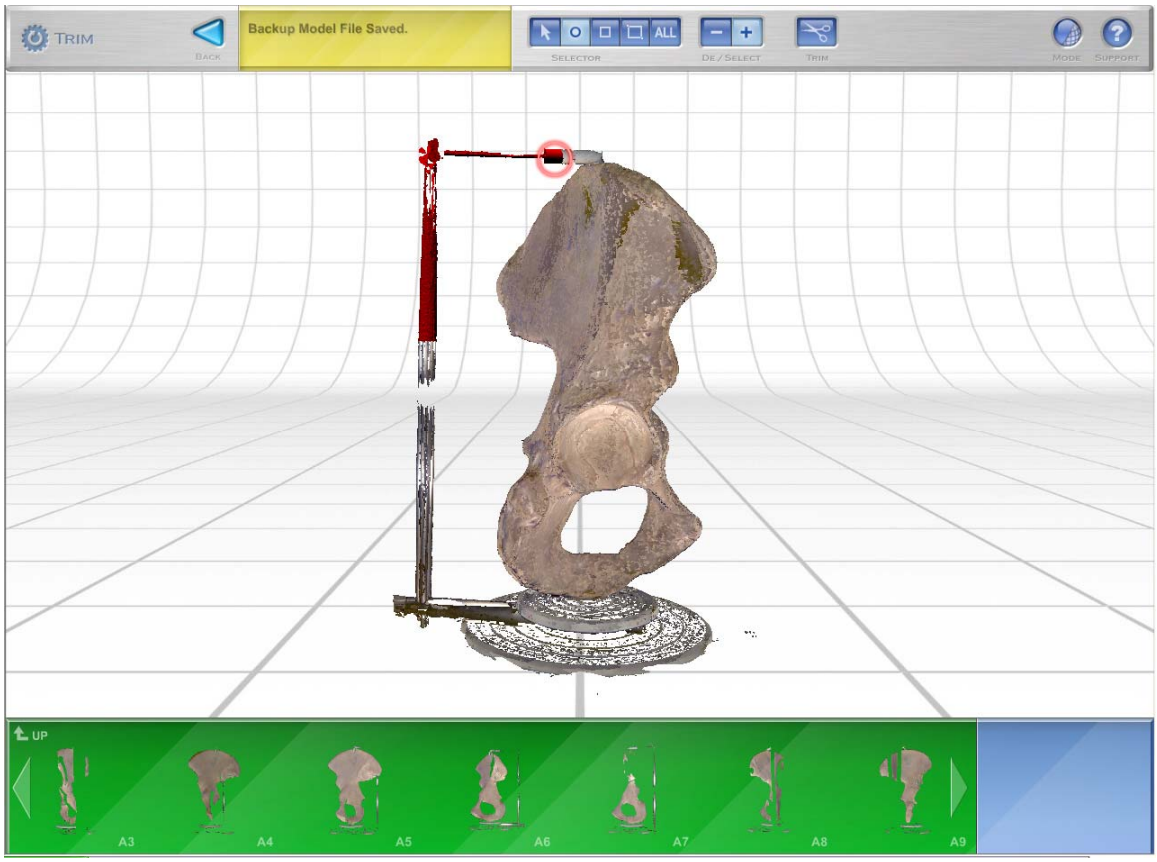

Figure 12: Trim tool

Fill - A number of holes may appear on the scan family which can be seen following alignment. Dark patches and deep concavities on the bone surface can bounce the lasers and leave holes in the scan. Smaller holes can be filled using the fill option in the editing tools. The scanner uses the surrounding environment to intelligently fill the holes accurately. Larger holes can be filled by scanning the object several times whilst mounting it on the turntable in several different orientations to capture the missing portions. These rotations can be aligned to the original scans. There is no limit as to how many families can be included in one file.

Fuse - The edited scan families are then fused to create a complete 3D model. This application merges each division of the scan family and fills any remaining unwanted holes. Dark areas such as shadows created in single divisions are often erased by this process as the software blends the texture of each division (Figure 13). Scan A

below shows dark yellow patches on the gluteal surface of the bone (circled) which have been merged following fusion as seen in image B.

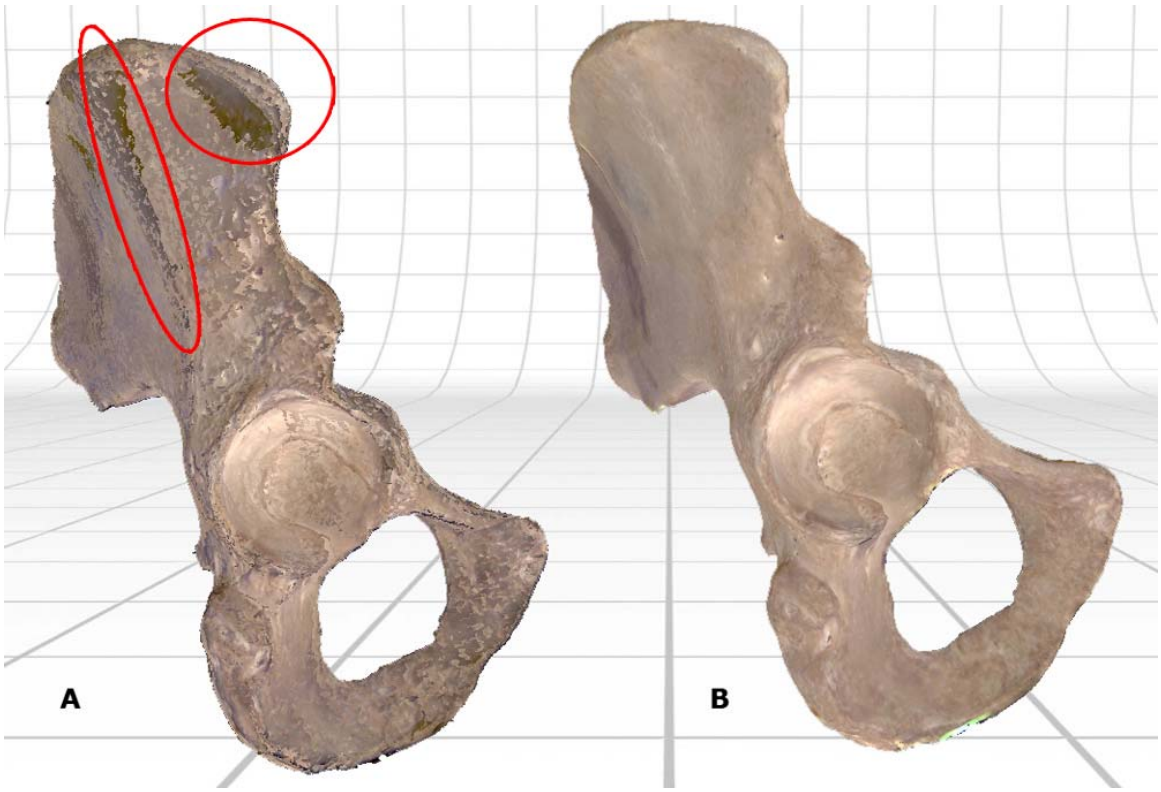

Figure 13: Image A is the aligned scan family before fusion (B)

Simplification - Once fused, a simplification process can be carried out to condense the file to a size suitable for export. The models are made up of millions of triangles which map the geometry of the object to the surface texture. File sizes may need to be reduced to make the file small enough for export. This involves decreasing the number of triangles and increasing the size of the remaining triangles whilst ensuring that suitable level of detail is retained (Figure 14).

Model A in Figure 14 has been simplified to create model B using the intelligent decimation feature in ScanStudio Core™ which reduces the number of triangles and increases the size of the remaining triangles, retaining acceptable detail of the model. For example, although the

overall number of triangles are reduced, complex areas will have a greater amount of smaller triangles to retain the detail of the model.

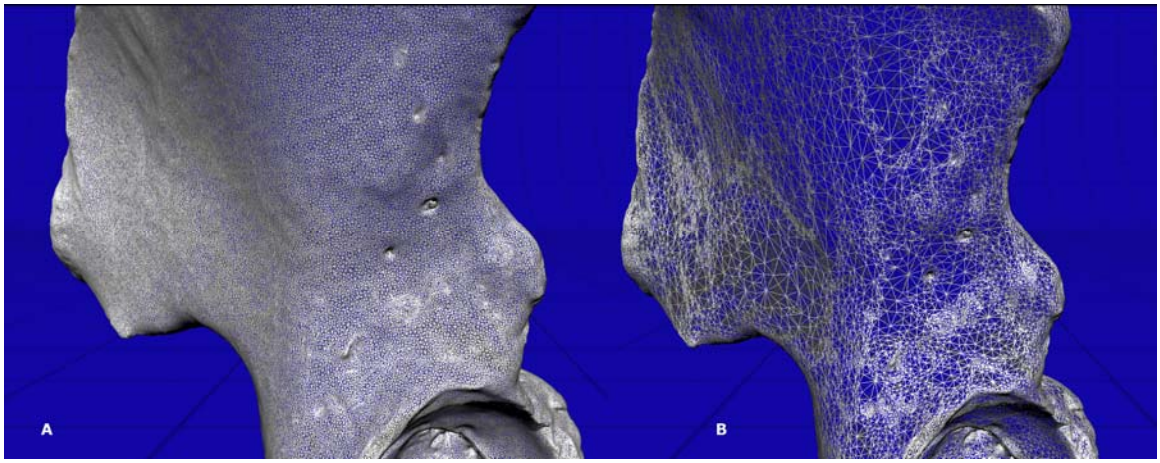

Figure 14: Image A - Before simplification Image B - After simplification

ScanStudio Core™ software allowed the captured images to be exported in OBJ, STL, VRML and U3D formats, allowing them to be used in 3D software packages such as Autodesk® MAYA® and 3DS Max where the models could be rendered and animated for the purpose of this project.

Discussion of the NextEngine™ Scanner

The NextEngine™ desktop scanner was ordered in June 2008 and was delivered in December 2008, causing initial delays to the project. There was no one within the University who had experience of working with the NextEngine™ desktop scanner and therefore self training further delayed the project. It was also apparent, but not confirmed that the software which was available upon purchase of the scanner (ScanStudio Core™) was being Beta tested on the developer's clients. Any problems incurred were reported to the developers and, in an attempt to solve the problem, the software was updated, suggesting the software was being client tested. The problems faced were not addressed directly by the company and this resulted in the software being updated approximately every week whilst the four specimens from the Scheuer Collection were being

scanned. Further problems were caused as options and features in the software continuously changed during the scanning period.

Following a series of updates in the software, the scanned images appeared to take on a bright appearance which lost the underlying texture and did not match the actual brightness of the bone (Figure 15). It was discovered that an option in the scan settings toolbar which was recommended for best accuracy had disappeared between the earlier software (1.5.5) and the latest software (1.6.3) which led to the bright appearance and loss of texture to the scans. This resulted in the software having to be regressed (i.e. the latest version uninstalled, and replaced with the earlier version 1.5.5) during the scanning process.

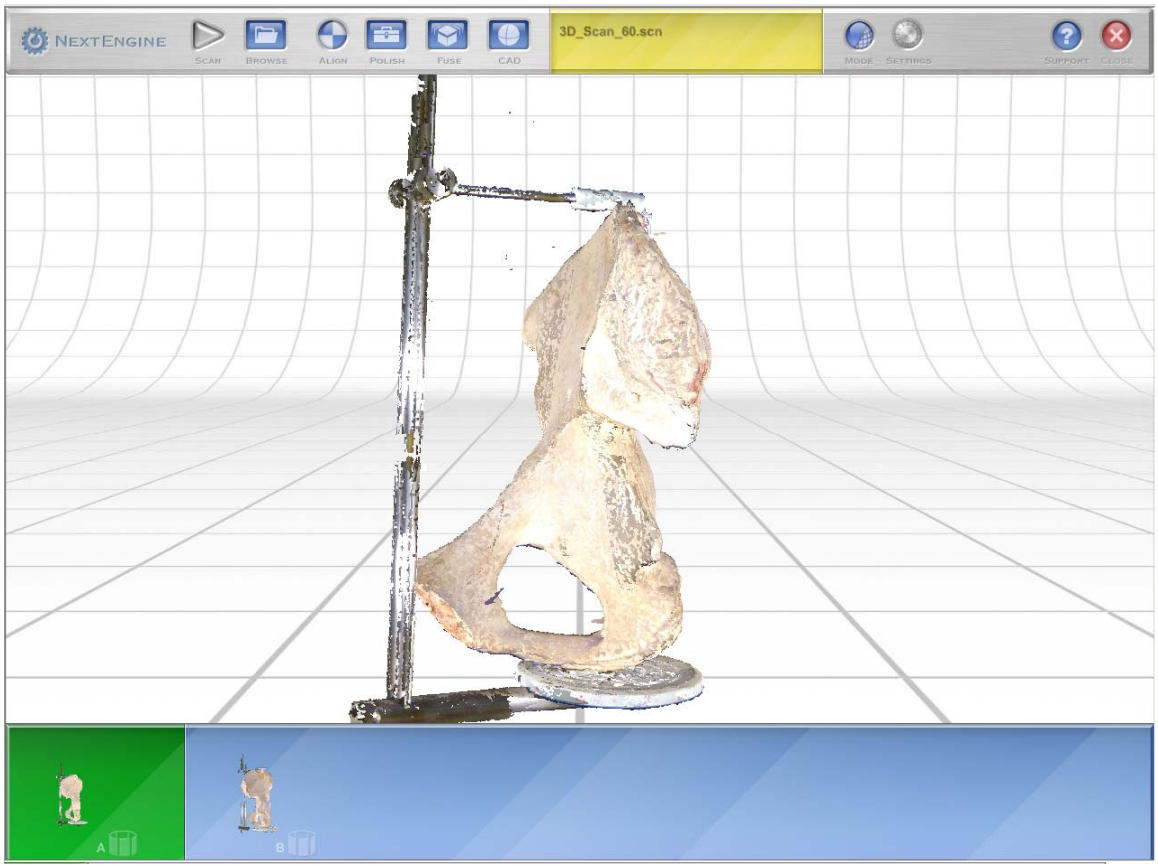

Figure 15: Bright appearance after scanning

This earlier software however, caused problems with the process of aligning and fusing the scans such as misalignment (Figure 16). Two

scans below are pictured, the scanner has automatically aligned them, however, they should align on top of one another rather than fused together on different planes as seen below.

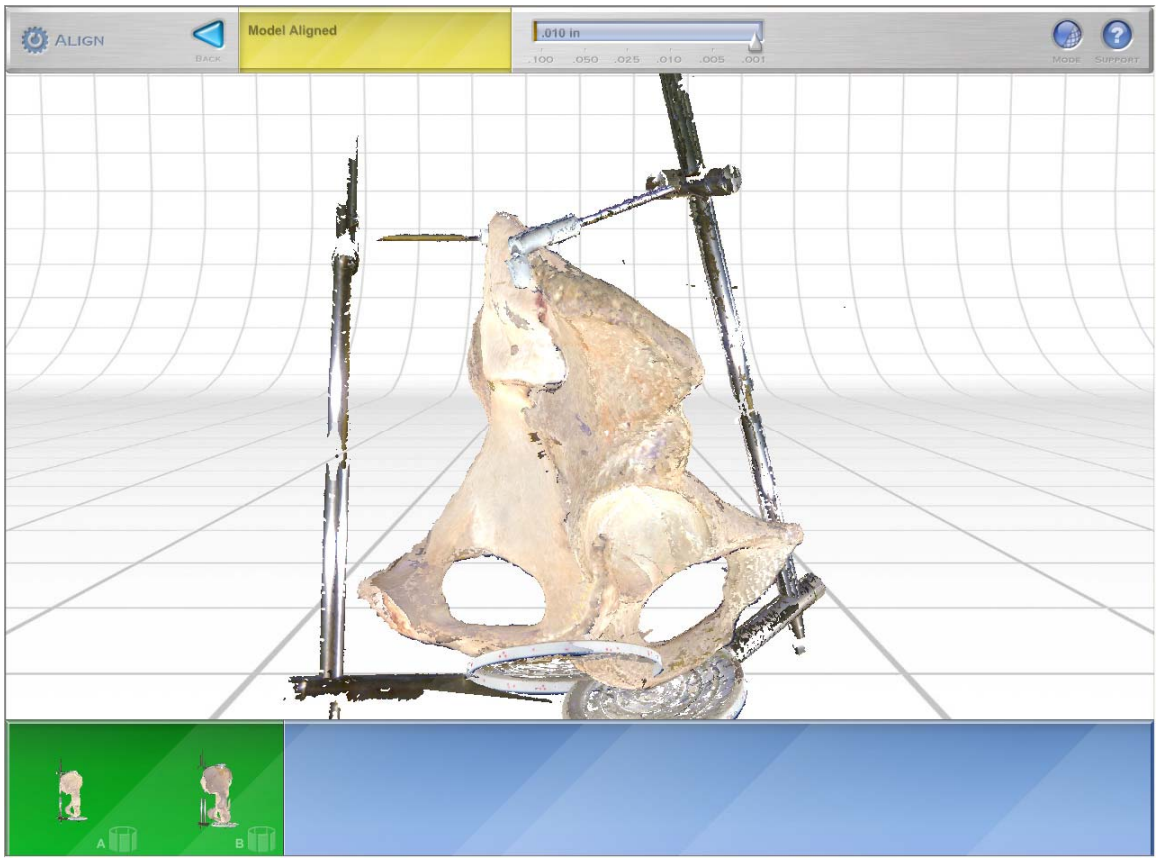

Figure 16: Misalignment of two full scans in 1.5.5 software

The 1.5.5 software also did not recognise the amount of RAM in the computer which caused frequent crashes when using the alignment and fusing features. These problems had been overcome in the update 1.6.3 software and therefore resulted in all the bones being scanned in version 1.5.5, and the process of alignment and fusion was completed in version 1.6.3 resulting in at least one hours work lost everyday, having to update and regress the software to the appropriate version as and when necessary. Since the auto-update function could not be turned off, the computer had to be disconnected from the internet to prevent the software updating itself each time it was used. This resulted in a lack of communication through the bug

system embedded within the software which reported problems and errors to support staff from NextEngine™.

Although glitches in the software of the scanner caused delays, the images it produced were of high quality and readily exported into Autodesk® MAYA®. However, the scanning process was long and without constant updating and backdating it could have taken a number of weeks rather than months. It was initially proposed that scanning would be complete within 4 weeks, however due the above software issues, this was extended significantly to over 2 months.

It could be suggested that should the project be successful and the entire Scheuer Collection requires digitisation, another method would be considered. Computed Tomography (CT) scanning may be beneficial as it is time effective and will record 3D data for future research projects using the Collection in addition to providing accurate 3D models easily uploaded into 3D modelling software such as Autodesk® MAYA® as used for this project.

Autodesk® MAYA® and Adobe® Flash®

For the models to look realistic, they required software manipulation which would provide lighting and movement of the object in a life-like appearance (for example Autodesk® MAYA®). Following the creation of the 3D virtual models in ScanStudio Core™, the files were exported and uploaded onto Autodesk® MAYA® for rendering. The process of rendering allows 2D images to be captured from 3D models and in this case was used to add lighting features such as shadows for the bones to appear more realistic (Figure 17). Rotation and lighting features were added using Autodesk® MAYA®. The red arrows below indicate the position of a spotlight. This was used to create shadows giving the bone a realistic look.

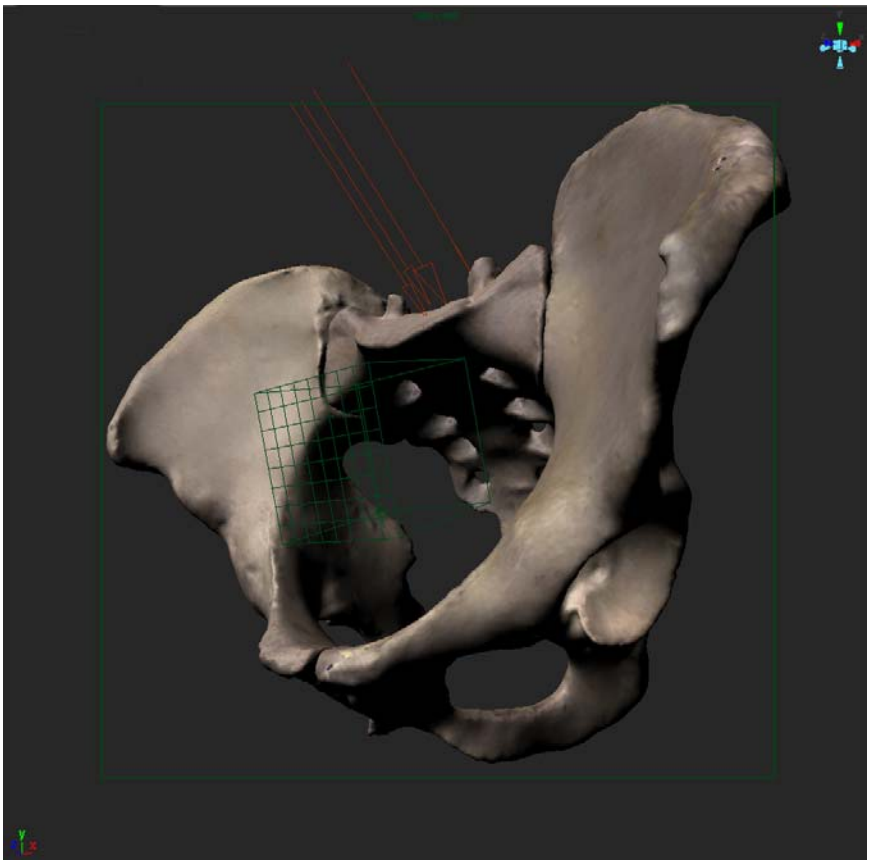

Figure 17: Screenshot of adult pelvis in Autodesk® MAYA®

For this project, teaching from 3D models was created entirely in Adobe® Flash® from JPEGs created in Autodesk® MAYA® in order to protect the information contained in the 3D model. A pseudo-3D effect was created using a flip-book method which did not require the use of the true 3D data contained in the 3D model. This method used a sequence of 2D images exported from Autodesk® MAYA® which, put together in Adobe® Flash® created a pseudo-3D effect which subsequently protects the true 3D data (collected from the scan) from being downloaded from foreign sources. This method is also beneficial as viewing the true 3D data within the module would require every user to have the appropriate 3D viewing software on their computer or would limit users location and time to specific hours within the College where the software is available.

The animation department in the College of Art, Science and Engineering (CASE) were contacted to render these models (using

Autodesk® MAYA®) and animate the model (using Adobe® Flash®). For this project the selected models were lit accordingly, placed in anatomical position and rotated 360° around a central vertical axis, with 2D JPEG snapshots taken at equal intervals. Approximately 250 JPEGs resulted from each rendered model in Autodesk® MAYA®. A selected number of JPEG images were uploaded into Adobe® Flash® from Autodesk® MAYA® to create pseudo-movement of each model in a flip book animation. Interactive content could be added to the images to label and highlight features of the bones.

These 3D effect animations were created to allow participants to move around the objects freely and also added interactive, practical tasks (such as labelling features on the bone) to the module. It was proposed that these animations would also be used along with text and sound recordings to address different styles of learning. These interactive features increased the level of interactivity of the module and intended to give participants more freedom in their studies.

Proof of concept:

In order to test the suitability of the animations for teaching purposes, one of the four models was selected to include a number of interactive activities for proof of concept. The remaining three models were used in the module as 360° rotations where participants could move them horizontally by dragging the mouse cursor. The proof of concept animation included the rotation feature as above in addition to highlights and explanations of important structures (Figure 18). This aimed to heightening the interactivity of that particular section of the module.

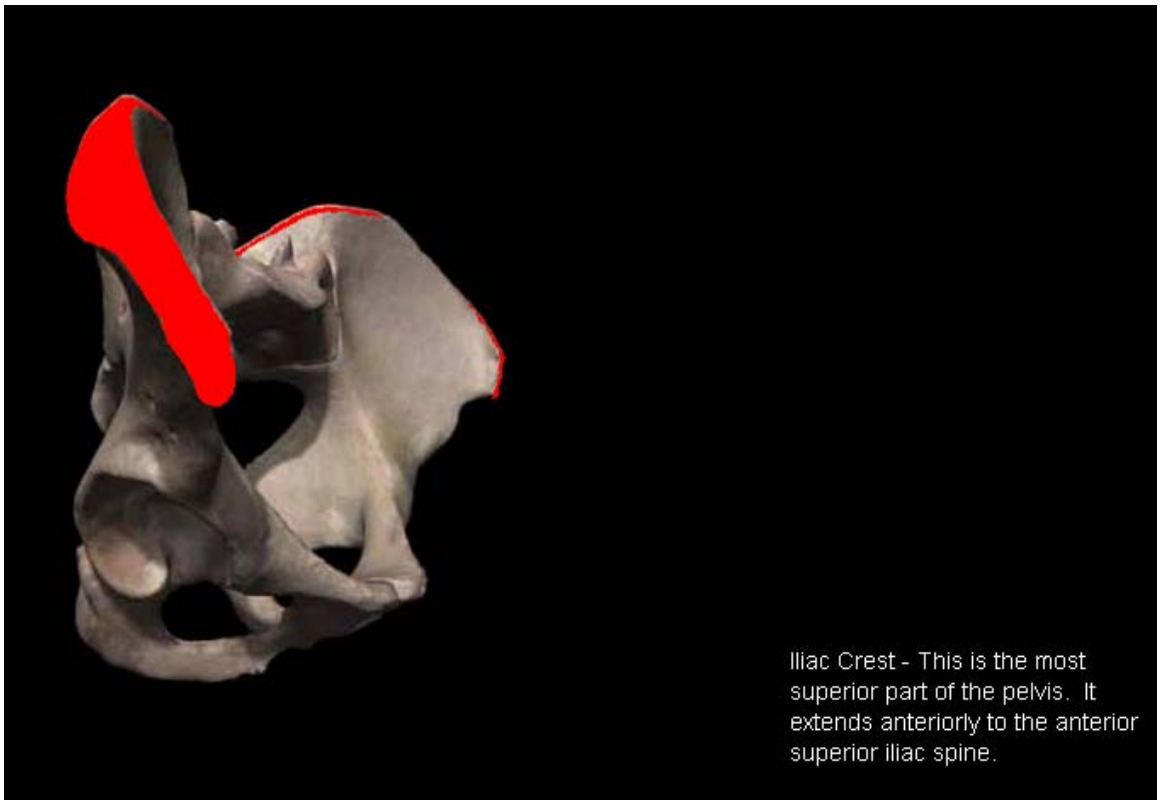

Figure 18: Screenshot of proof of concept

Only one model was selected to be tested on participants as its suitability for teaching osteology was unclear. Students evaluated the module which had specific questions comparing the proof of concept to the 360° rotations (which had less interactivity). Positive evaluation of the proof of concept would indicate this method could be pursued if the module was to expand in the future into teaching the development of the entire skeleton.

Discussion of Autodesk® MAYA® and Adobe® Flash®

Initially, it was proposed that all aspects of the project would be completed by the author. A number of problems occurred due to insufficient software within the College of Life Sciences and the inexperience of the author with imaging and animation software such as Autodesk® MAYA®–and Adobe®Flash®. Therefore other sources were contacted for the use of the appropriate software and aid from the relevant trained individuals was pursued.

Software available to the department for rendering the models from the desktop scanner was unobtainable. Licensing issues arose upon purchasing Autodesk® MAYA® which would delay the project further and therefore other options were considered. CASE at the University of Dundee had the relevant software (Autodesk® MAYA®) and licensing for the product already in place and were approached for collaboration with the model rendering aspect of the project.

It was discovered that learning to use this software effectively was not possible within the time constraints of the project and therefore animators from CASE at the University of Dundee were approached to render the models suitable for exportation into Adobe® Flash®. Similar problems regarding software training were also experienced when animating the rendered images in Adobe® Flash®. Although training the author would have been more suitable, time was limited, therefore CASE was approached to assist.

Rendering the models in such a way that they could be exported into Adobe® Flash® where a number of interactive features could be added also proved to be extremely time consuming using Autodesk® MAYA®. The proof of concept allowed the animators to work on one complex interactive activity for users to compare it with the simpler 3D rotations. In addition to highlights on the proof of concept, interactive quizzes, a zooming tool and multiple directions of rotations were considered; however these also proved to be time consuming therefore the resulting proof of concept only included highlights on the bone and an explanation of these features. The proof of concept was used in the final module in conjunction with 2-D images and simpler 3D rotation animations which had less interactivity.

This preliminary project has initiated future collaboration opportunities between the University's CAHID and CASE. The discussed project forms the initial suitability testing of a larger project. It is proposed that if the project is successful this collaboration could result in an online interactive course teaching the development of the entire skeleton from fetal age to adulthood, with the possibility of extending to the full discipline of forensic anthropology. Project grants and funding opportunities are currently being explored.

Adobe® Photoshop®

In addition to 3D animations, 2D images were included on the module in areas which did not necessitate 3D delivery. This graphics editor is used for bitmap and image manipulation using tools such as highlighters and erasers. The tools within the program can be utilised to manipulate images for educational purposes. In the case of teaching the development of the skeleton, several images can be taken and edited to highlight specific features to heighten understanding. In the following example (Figure 19), a digital image of an innominate was taken (A) and changes to the background, lighting, scale, colour and text (B) have been used to explain the bones contributing to the acetabulum using tools available in Adobe® Photoshop®.

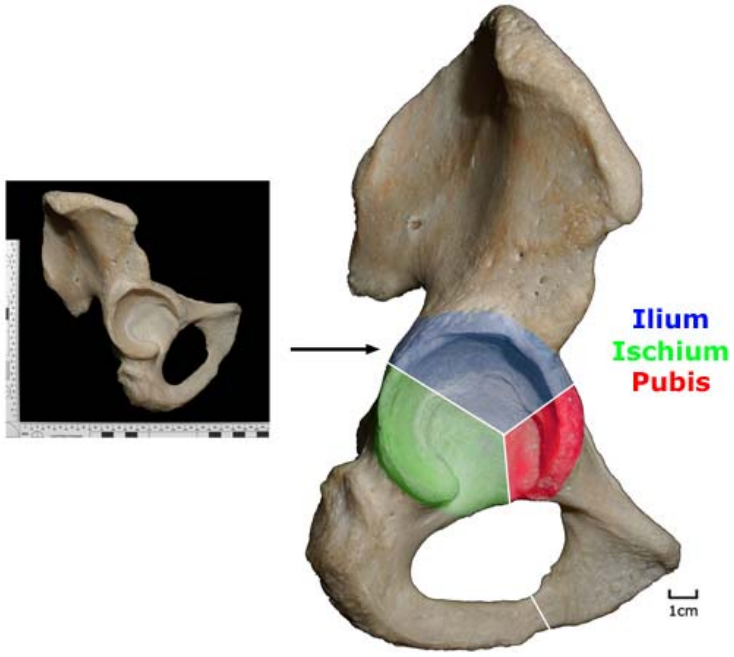

Figure 19: Image B has been manipulated from the original digital image (A).

The 2D images were simple to produce and therefore a large number were included in the final module. These images were mainly used to teach less complex features in the bone which did not require 3D understanding, however in some cases they were used primarily to discuss features in 2D in conjunction with the 3D animation with the aim of increasing understanding. Images of a number of specimens from the Scheuer Collection were used in the module aged from birth to late adolescence to cover the large spectrum of the development of the innominate.

3.2 Creation of the online module "Developmental Osteology"

The project utilised the facilities within the University of Dundee's VLE; "*My Dundee*" (from Blackboard Academic Suite™ 8.0). This readily accessible platform allows controlled access to participants and provides them with a variety of tools for education and communication. It also provides a secure area where administration can be carried out by the instructor (author).

Initially a storyboard was compiled to organise the layout and the content for the module (Appendix 4). "Developmental osteology" was the name given to the test module created on "*My Dundee*". Academic materials were uploaded to create the teaching material to be tested on the module, administration tools were made available to the instructor in order to track and assess enrolled participants and communication tools were made available in a variety of methods (e-mail, discussion board, and announcements).

Tutorials were introduced onto *"Developmental Osteology"* which focused on the development of the innominate. Initially this bone was addressed in its adult form to allow participants to have a basic understanding of the adult osteology before completing a subsequent tutorial on its development (Appendices 5 and 6). Understanding the adult bone before addressing the juvenile form is useful as features can be explained in their fully matured adult state making understanding juvenile development easier by knowing what the small immature elements will become following maturation.

Students undertaking the undergraduate degree in forensic anthropology at the University of Dundee have had some previous exposure to the adult form in secondary education as all entrants

have previous biological experience. In addition to this, students are re-introduced to the adult skeleton in level two. Here they learn basic human osteology. This prepares them for level 3 where they dissect the human body and visualise the skeleton *in situ*. At this time they also learn the development of the skeleton using the Scheuer Collection. Handling these specimens is extremely worthwhile for understanding the development of particular features of the immature skeleton (Pers comm. Adam McLean, level 4 undergraduate). However, the growing number of students and researchers gaining access to the material leaves the fragile collection susceptible to damage and other methods of dissemination must be considered.

The use of numerous dynamic, creative, educational experiences was introduced onto the module to address the issue of digital learning from the collection. Tools such as discussion boards, hyperlinks, sound and interactive software (Articulate® ENGAGE) in addition to the 3D animations discussed previously other features such as 2-D images, discussion boards, announcements, hyperlinks, highlighted text, drag and drop activities, glossary, and tests were added to the module with the aim of engaging the learner.

Discussion board

This communication tool provides a forum where students can (anonymously) leave comments regarding the course. Comments (or questions) can be directed to their peers or the instructor and are open to all users. Farmer (2004) reported discussion boards to be the primary method of communication on VLE systems. Discussion boards have been found to be useful as they encourage users to overcome problems in a group by posting comments that their peers (and instructors) can answer (Conole *et al*., 2002). Social discussion boards and discussion boards with specific subjects can be created,

however, in this module only one discussion board was introduced for general discussion purposes.

Announcements

An announcement page was created for a second alternative method of communication. This was used to post information regarding deadlines, delays and information to keep participants up to date with the project. Although participants were not tracked to view this page, the announcements page was a useful alternative to e-mailing.

Hyperlinks to journal articles and websites

Relevant journal articles were made available via hyperlinks which opened in a new window and could either be read onscreen or printed (Figure 20). This reduced the amount of text within the module and provided an element of interaction for the users by clicking available links.

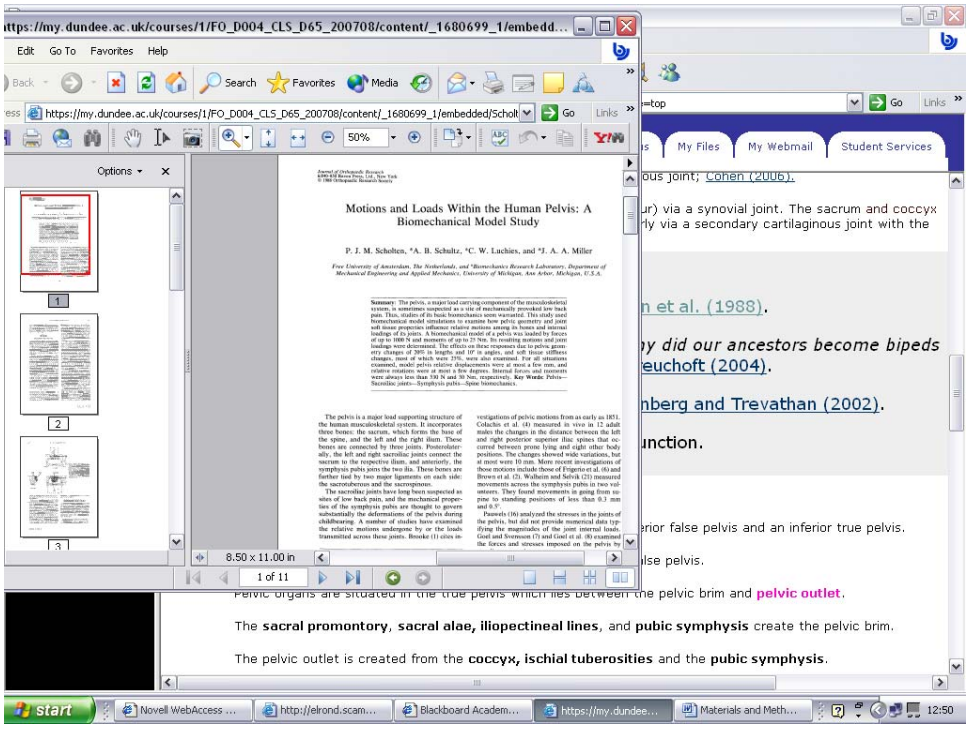

Figure 20: Journal article (above) hyperlinked from the module

Hyperlinks were included for participants as optional extra reading activities giving them guided freedom with their studies. Oliver and Herrington (2001) reported that students take control of their learning when publications are available from a hyperlink. They also report the inclusion of hyperlinks to be more "*conducive to learning than reading alone*".

As this one year project was limited to the development of the skeleton, an overview of the development of bone was hyperlinked to the module from an external source (freely available online) (www.training.seer.cancer.gov/module_anatomy/unit3_3_bone_growth) in the same way the journal articles were linked (Figure 21). In the future this aspect would be considered as a tutorial in itself, however for the purpose of this project it was addressed through another source.

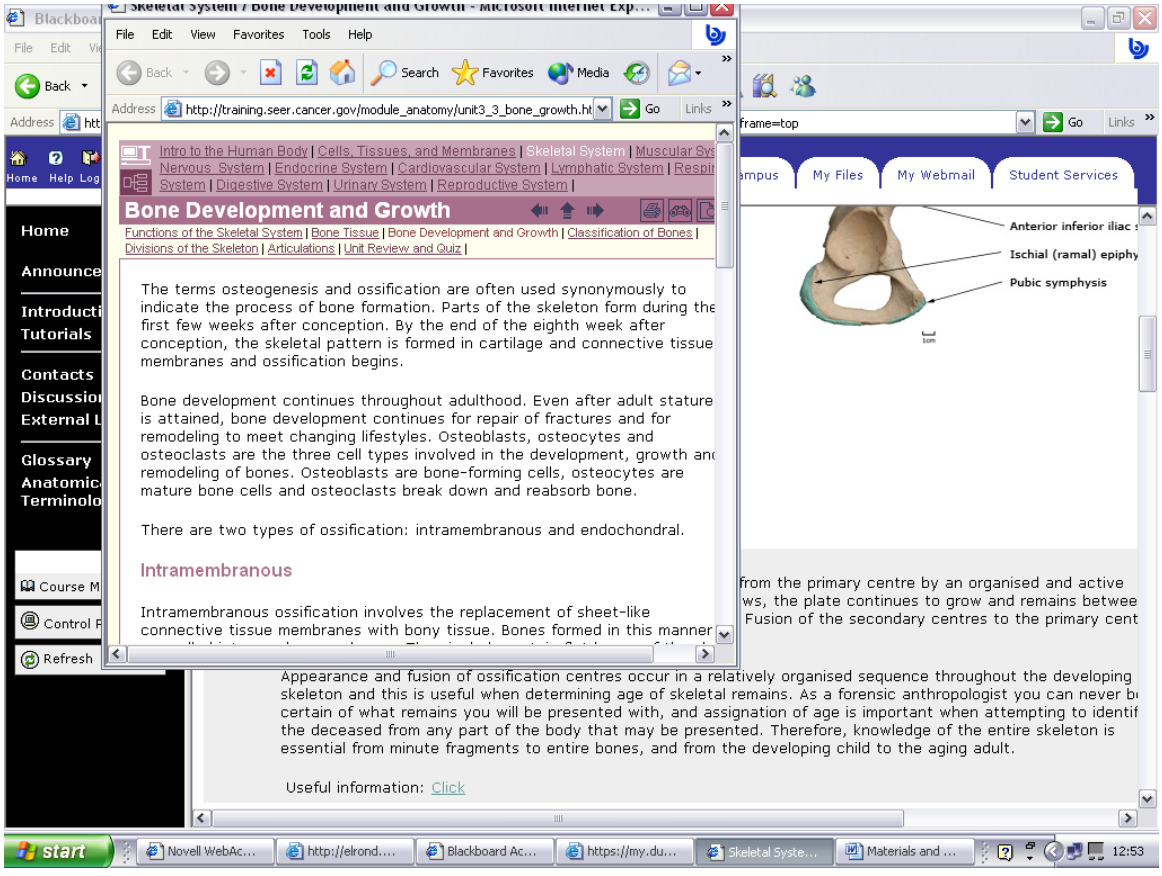

Figure 21: A bone development website (above) hyperlinked from the module.

Issues of copyright are overcome by redirecting links to the vendors website where the desired article is freely available. An article not freely available online would require the permission of the author. The library staff within the University of Dundee were contacted for advise on copyright issues and suggested that including links to journal articles which are freely available online can be used for educational purposes (Pers comm. Beveridge, 2008).

Adobe®Flash® animations

Interactivity in online learning should involve engaging, questioning, discussing, inquiring, problem-solving and evaluating features for users (Liaw and Huang, 2000). Northup (2002) reported that too much interaction can be interpreted as "busywork" and not necessarily be appealing to users. On the other hand, too little interactivity can be isolating and unstimulating for learners. Therefore, this project aimed for an intermediate status: 3D animations were included to highlight key, complex features on the developing pelvis. Interactivity was heightened in this area as users were able to move and interact with the animations freely.

Drag and drop activities

A website freely available online was used to create simple drag and drop activities for the module (www.webducate.net/dragster.php). JPEGS were uploaded onto the site and labels were created for users to drag the label to the appropriate point on the image. This tool was simple to use and provided interactive activities to include on the module. These activities were not tracked, but users were given feedback and had the ability to complete the activity as many times as required.

Glossary and Anatomy terminology pages

To avoid lists of words in a glossary, an interactive software program (Articulate® ENGAGE) was used to construct a glossary (Figure 22 **A**) and an anatomical terms page (Figure 22 **B**). These tools were made available on the contents list which was always visible to the user (Figure 22 circled) allowing them to look up required terminology at any time. Specific terms were hyperlinked to the glossary to encourage participants to look up their meaning.

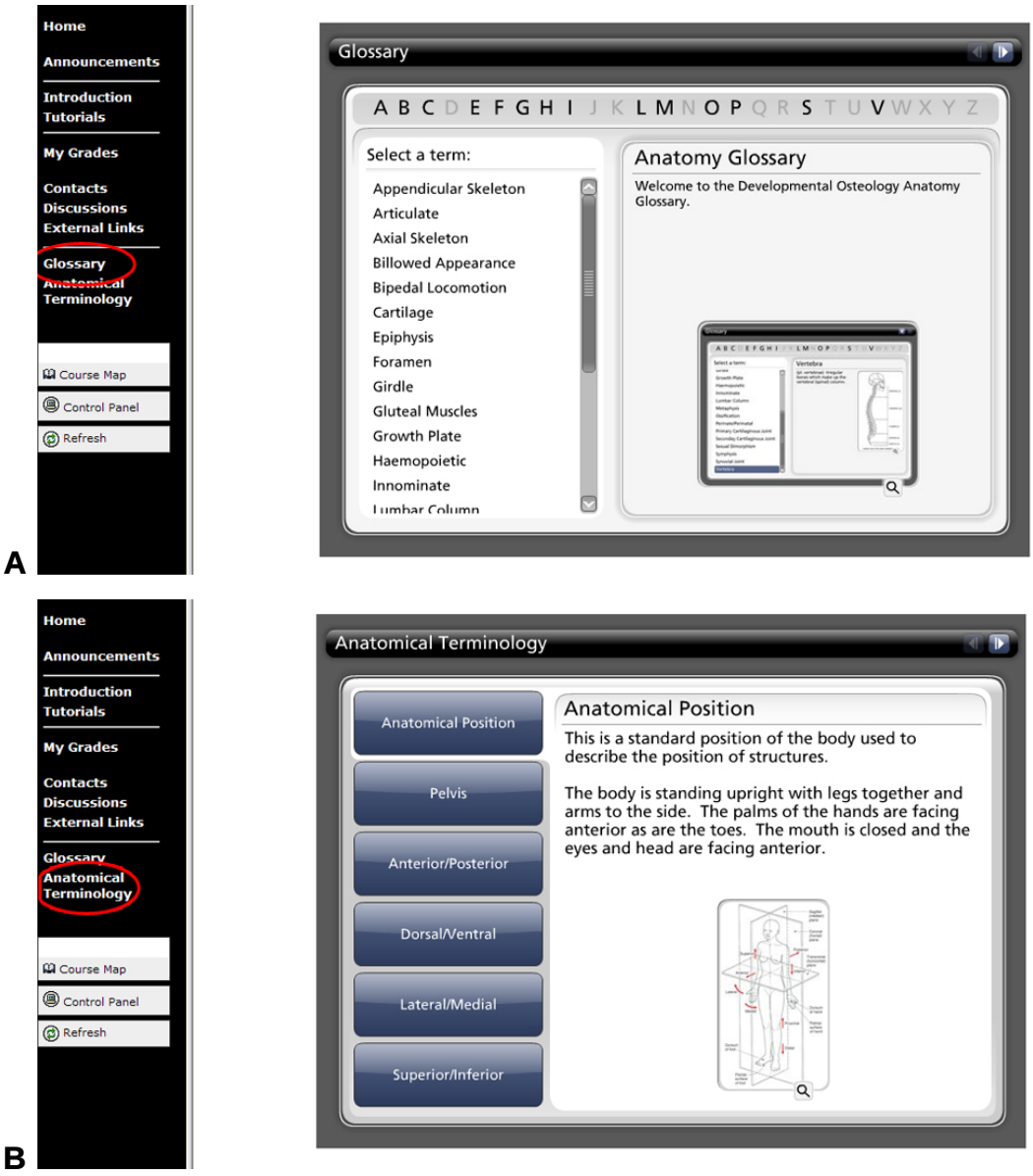

Figure 22: Glossary (A) Anatomical terminology page (B)

This software provides easy to use templates, to which text and images can be uploaded. Similar to Adobe®Flash®, Articulate®

ENGAGE provides a means of delivering information in a way that students can interact with the content, and therefore minimise passive learning.

The Learning Centre at the University of Dundee were currently testing this piece of software and therefore they carried out the conversion from text and image format into the current appearance on "*My Dundee*" (Figure 23). The purchase of this software in CLS would be considered in the future if the project is to continue.

Sound

Sound features were considered for this module to engage different learning styles rather than rely solely on continuous text. However, the WYSISIG feature of "*My Dundee*" would upload sound recordings, but could not play them back. The support of The Learning Centre was sought; however the sound recording application had proved problematic in other subject areas (Pers comm. Walker 2008). This method of teaching also relied on participants having up-to-date media players, therefore it did not seem a reliable or realistic feature for this project.

Questionmark™Perception™

Determination of the suitability of e-learning involved both assessment and evaluation of the module. Students were assessed by the inclusion of tests and evaluations which were undertaken online. Questionmark™Perception™ was the assessment management system used for the project. It allowed educators to create, deliver, and report on exams, quizzes and surveys.

Content from the information contained within the tutorials was converted into an assessment format using the Questionmark™Perception™ software (Appendices 7 and 8). These

tests were available online, but also had the ability to be printed out in the event of a system failure. Users were given access to the tests before and after completing the tutorials. The results before and after were compared to determine the extent of academic achievement, as evidenced by an improvement in examination performance. Students were advised not to guess in the initial tests but rather to state that they did not know the answer. This allowed the test before and after the tutorial to be compared more effectively.

Questionmark™Perception™ was used to assist in the evaluation of the module. After the first test (Appendix 7) the participants were given a short online evaluation form (Appendix 9) which asked a number of questions relating to their opinion of the test. Questions on the timing, clarity, layout, and difficulty were included in addition to the relevance of the online test for examination and revision purposes. Creation of the tests was simple and required little training. A wizard creating feature was available in the Questionmark™Perception™ software therefore the author created the majority of the questions with the aid of Dr. Walker, a learning technologist at the Learning Centre.

"My Dundee" provided a platform to allow the tests and surveys to be uploaded and accessed from the module with ease. *"My Dundee"* also enables student progress to be tracked in a grade book format, which was used to collect the assessment and survey data for this project. The data was stored securely on *"My Dundee"* where only the administrators (the author and supervisor) had access rights to the grade book facility.

The resources discussed above were all uploaded onto "*My Dundee." "My Dundee"* provides user-friendly "what-you-see-is-what-you-get" (WYSIWYG) software which allows the course to be created without any prior knowledge of HTML or web-design. In contrast, traditional

methods of web creation use coding such as HTML and do not provide a means of viewing the resulting page whilst it is being edited. WYSIWIG refers to a type of user interface which allows the creator to view what they are creating (a web page for example) during the editing process. Images and animations etc. can be copied and pasted onto a WYSIWYG and can subsequently be re-sized and scaled and arranged onscreen (Figure 23). The layout can be made consistent throughout the module or can be made individual to a tutorial or test.

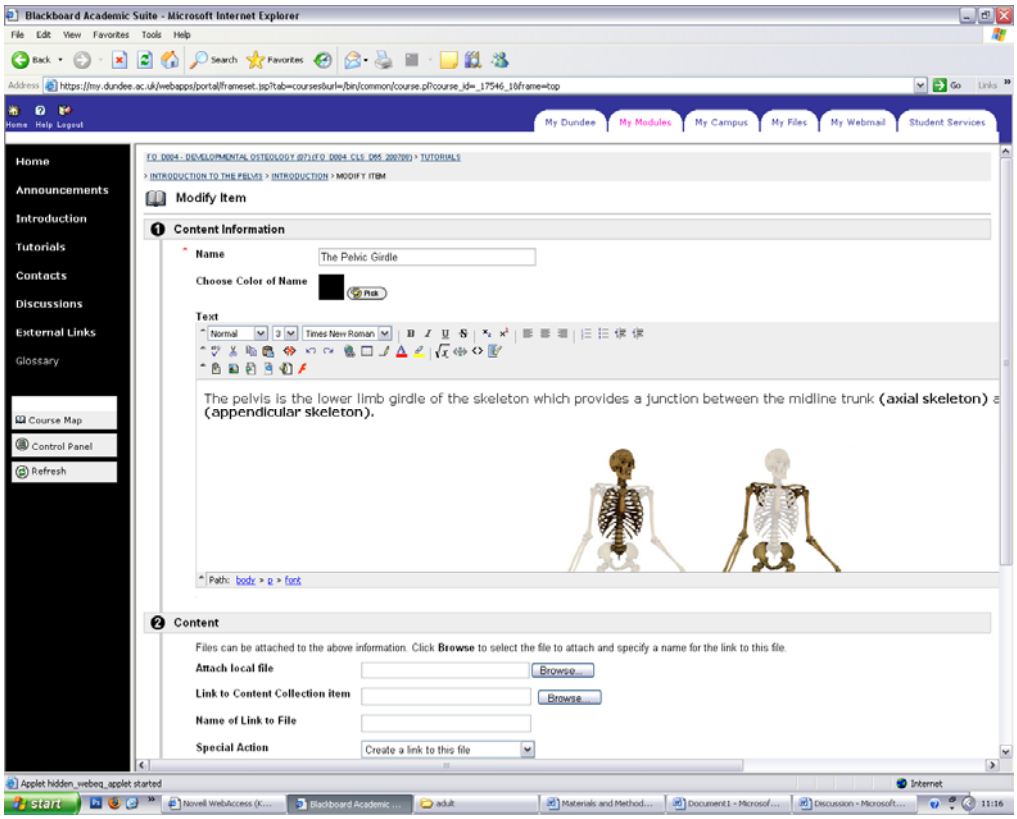

Figure 23: Screen shot of *My Dundee* during the creation of a page.

Overall "*My Dundee*" was an effective, efficient platform to deliver the module "Developmental Osteology" online. From a creator's perspective the module was relatively simple to construct due to the WYSIWYG feature. Little training was required and knowledge of HTML was useful for more complex functions but not essential.

This software was extremely useful for assessing and evaluating participants' progress. As the software is compatible with "*My*

Dundee", it was simple to track participant progress whilst maintaining confidentiality of results.

3.3 Participants and the project

105 students/staff were enrolled onto "Developmental Osteology" on "*My Dundee"*, including; level one to four forensic anthropology undergraduates, postgraduates and staff members (level 5) within the Centre for Anatomy and Human Identification (Table 4). It was proposed that participants would undertake assessments and tutorials throughout the academic year and their progress would be followed by the application available in the *"My Dundee"* software: grade book. However, time delays resulted in the majority of the module being completed in October 2008.

As this was a one year project; the development of the innominate was addressed first. Later, if the project proved to be successful, the entire skeleton may be considered. This region of the skeleton was selected as there are challenging educational concepts which must be conveyed and these will be tested for their suitability for online delivery. The module was split into a number of tutorials with relevant tests. The storyboard was used to create each individual tutorial and test, prior to inputting any material onto the VLE (Appendices 4 and 5).

Assessment of the teaching material was addressed by comparing results of a pre test, taken before the participants had access to a tutorial (status 1) with results from the same test taken after the participants had completed a tutorial (status 2). Participants were not told the tests in status 1 would be the same as those in status 2 to avoid participants looking up the answers for status 2. However, by tutorial 2, participants may expect this to be the case. There

were two tutorials, each with a test taken before the tutorial (status 1) and the same test after completing the tutorial (status 2). Tutorial 1 and test 1 was based on the adult innominate (hip bone) and tutorial 2 and test 2 focussed on the development of the innominate.

In addition to the comparison of the test scores between status 1 and 2 for each tutorial, a number of evaluations were undertaken to gain participants opinion on the online module. There were four in total; one taken following test 1 (at status 1), the second and third were taken after tutorial 1 and 2 respectively and the final evaluation was undertaken after completion of tutorial 2's evaluation. The data collected from the tests and the evaluations were then used to assess the module. Table 2 and 3 are a timeline for the project.

STATUS 1		**STATUS 2**	
Activity	**Date**	**Activity**	**Date**
Pre test 1	Nov 2007*	Tutorial 1 and test 1	Oct 2008
Pre test 2	May 2008*	Tutorial 2 and test 2	Oct 2008

Table 2: layout and timing of completion. * Sept 2008

EVALUATIONS	**Date**
Pre evaluation	Nov 2007*
Evaluation of tutorial 1	Oct 2008
Evaluation of tutorial 2	Oct 2008
Final evaluation	Oct 2008

Table 3: layout and timing of completion. * Sept 2008

Participants were contacted and their participation in the project was requested in October of 2007 by e-mail. "Developmental Osteology" became live to participants in November 2007 where they were given access to a discussion board an introduction page and an

announcements page. The announcement and discussion board pages were used as alternatives to contacting the participants via e-mail. The discussion board also offered participants an alternative to e-mailing for contacting the instructor or their peers. The introduction page contained background information on the project and gave participants information and instructions for the module (Appendix 10).

In addition to the background information on the introduction page, the first pre test and evaluation were made available. As participants were being assessed on what they learned from the module, pre tests were taken in order to assess what participants knew prior to being exposed to the teaching material. Questions within all the tests gave participants the option of answering "don't know." Participants were advised to use "don't know" to avoid guessing or looking up the answer.

The first pre test (Appendix 7) and evaluation (Appendix 9) became available in November 2007 and participants were given 2 weeks to complete them. The second pre test (Appendix 8) became available in May 2008. Participants were contacted via e-mail and given a month to complete the second pre test. As this test was available outwith semester time, participants accessing the module at this time were subsequently testing the module at a distance.

Creation of the tutorials was completed in August 2008. As this was outwith the undergraduate academic calendar it was decided that participants would complete these in October 2008. This subsequently increased participation as new students starting in academic year 2008/2009 consisted of 33 undergraduates (level 1) and 5 postgraduates were contacted to request their participation in the project. These students were enrolled on the test module in

September 2008 and given 3 weeks to complete both pre tests and the initial evaluation (Table 2 and 3*).

Following completion of status 1, all participants were given access to the subsequent tutorials. Each section of each tutorial could only become available following completion of the previous section to prevent participants missing out sections of the tutorials. After each tutorial was completed, the same tests that were available in status 1 were available again for participants to complete in order to compare results before and after being presented with the learning material. Evaluations were made available after each test and at the end of the module (Appendix 9) to acquire the opinion of the participants on the timing, layout, and individual thoughts on the module.

Participants were given 3 weeks to complete the module and given access to a grade book feature to follow their progress. Data collection was completed in October 2008. The participant numbers for completion of each status by each level can be seen in Table 4.

	STATUS 1		**STATUS 2**	
LEVEL	**Test 1**	**Test 2**	**Test 1**	**Test 2**
1	29	26	29	26
2	13	14	13	14
3	23	26	23	26
4	19	19	19	19
5	18	20	18	20
TOTAL	**102**	**105**	**102**	**105**

Table 4: Student participation for status 1 and 2 of the module.

3.4 Analysis of data

The raw data was uploaded from the VLE grade book within "Developmental Osteology" onto Microsoft Office Excel (Appendix 11). The data was then uploaded into Sigma Stat for statistical analysis and converted into figures using Microsoft Office® Excel.

A number of assumptions about the data were made. Firstly, scores which exceeded the time limit were not counted towards analysis as they did not represent a complete test (16 in test 1 and 3 in test 2). Also, questions left blank were counted as "don't knows" as participants were given the option to leave the question blank if they did not know the answer.

The raw percentage data did not fit a normal distribution curve and required the use of non parametric tests to analyse the data. In an attempt to transform the data to a normal distribution the percentages were converted into proportions and the arcsin square root was calculated. This process would allow parametric tests to be undertaken. However, this failed in some cases as the transformation does not work well if there is a substantial proportion of the data equal to 0 or 1. The arcsin transformation data was used in the analyses for significance but the use of normality tests was subject to each individual calculation as in some cases these failed, resulting in non parametric tests being used on the arcsin data.

Analysis of variance (ANOVA) is a statistical technique used to show the difference between means. These were used on the collected data to observe if any significant changes observed between status 1 test score compared to the test score obtained in status 2. In addition to testing combined participant scores, individual groups

(levels) were also analysed for statistical differences between status 1 and status 2 scores.

In order to highlight any concerns regarding responses to individual questions, chi-squared calculations were conducted. These were carried out on correct, wrong and "don't knows" answered in status 1 and 2 individually. If tutorials had no effect on answers no significant differences would be found.

These analyses will aid in the determination of the suitability of "Developmental Osteology" as a learning resource. Positive results would suggest that participants have learned the content of the questions between status 1 and 2.

In addition to analysing the effectiveness of the module, the approach taken must also be evaluated. This will be analysed through the data collected from evaluations taken throughout the completion of the module. This data will be addressed through charts and discussion of individual opinions.

Chapter 4.

Results

Before considering inputting online supplements or converting a course into an online format, it should be tested for its suitability (O'leary and Ramsden 2002). This chapter will discuss the data obtained from testing and evaluating the online activities discussed in Chapter 3.

The online module created for the project consisted of 2 tutorials, each with a test to be undertaken before access was granted to the tutorial (status 1) and a further test taken after completing the tutorial (status 2). Four evaluations were also completed at prescribed intervals throughout the participants' completion of the module.

This chapter aims to address two concepts from the collected data:

1. Whether participants learned from the online material
2. To gain participants opinion on various aspects of the course.

Two types of data were collected from the module; assessment data and evaluation data, which will be used to draw answers for concepts 1 and 2 respectively.

4.1: Evaluation of the Suitability

Evaluation of the suitability of the teaching material required using the assessment data. Participant's percentage score from the each test at status 1 was compared to the score obtained from status 2. Any differences demonstrated between scores were analysed for the significance level to determine if the tutorials had a positive, negative or indifferent effect on score. It was hypothesised that participant scores would increase in status 2 (compared to status 1) as participants completed the online tutorial between these stages. This included the information which was then assessed in the subsequent test.

Figure 24 shows the average score obtained in status 1 and status 2 for all participants (regardless of their level or experience) for both tutorials. As seen below, there is a large increase in score from status 1 to status 2 for both tests which is more pronounced for tutorial 1. This suggests the tutorials have had a positive effect on score. Statistical analyses were carried out for each test to observe any significance in these findings.

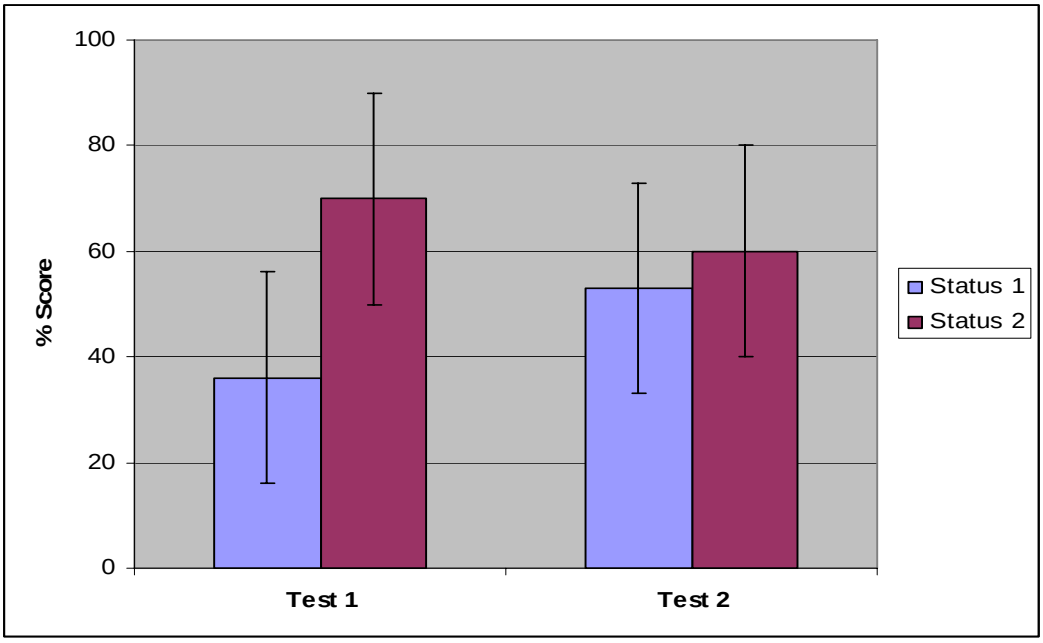

Figure 24: Status 1 and status 2 test scores for tutorial 1 and tutorial 2.

One way ANOVA results for test 1

The differences in the median values between scores in status 1 and scores in status 2 for tutorial 1 are greater than would be expected by chance. Therefore there is a significant difference between scores obtained in status 1 compared to scores obtained in status 2; ($H=54.616$; $p<0.001$) demonstrating status has a relationship with score and that the participants have learned additional information that has improved their score in the test.

One way ANOVA results for test 2

The differences in the median values between scores in status 1 and scores in status 2 for tutorial 2 are greater than would be expected by chance. Therefore there is a significant difference; ($H=59.126$; $p<0.001$) demonstrating status has a relationship with score and that the participants have increased their knowledge base which has improved their test score.

Further analyses were carried out in order to understand the data and the possible effect of the online tutorials on participant scores.

4.1.1: Test 1 Analysis

As participants were from mixed levels, statistical analyses on scores from status one and two were undertaken for each level to observe whether level and status had an effect on the score of test 1.

Figure 25 demonstrates an increase from status one compared to status 2 for all levels of experience suggesting that tutorial 1 had a positive effect on all the participants. The error bars on the chart suggest there is a significant difference between status one and two for levels 1 - 3. However, level 4 and 5 show a smaller decrease in

score between status 1 and 2 which suggests status may have had a lesser effect on score in these groups.

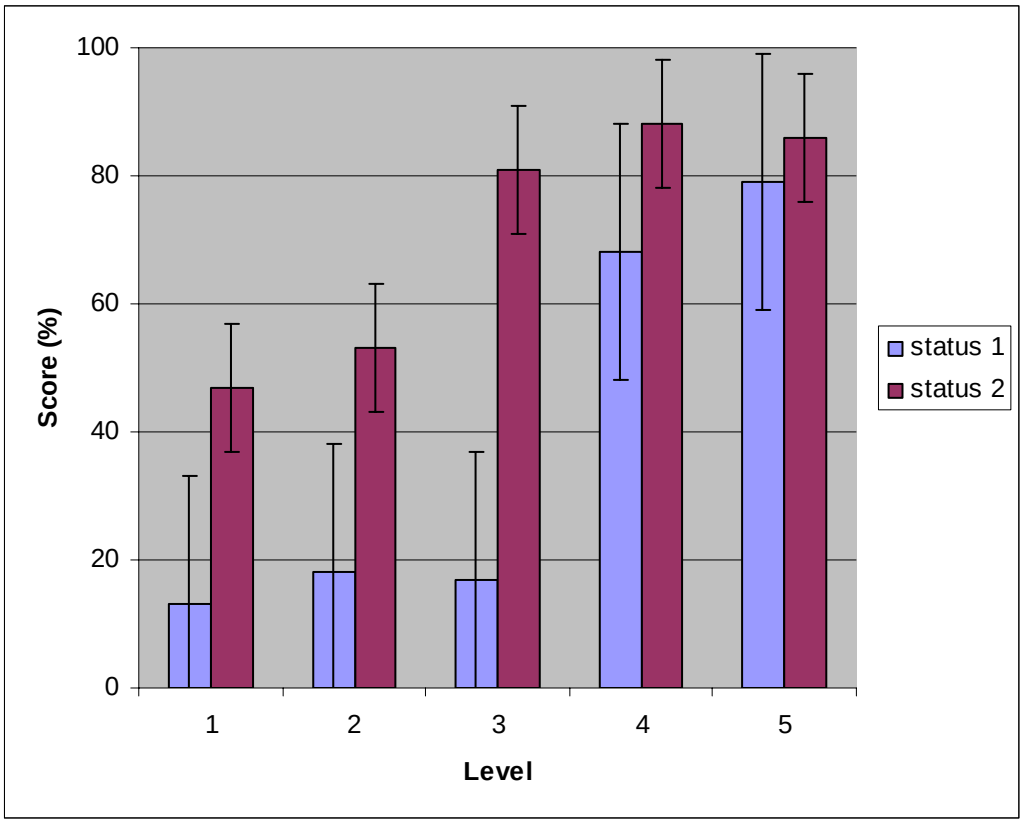

Fig 25: Tutorial 1 scores for each experience level for status 1 and status 2.

A two way analysis of variance was carried out to test if there was an interaction between level and status. The test demonstrated a significant difference between status and score ($F=253.719$; $p<0.001$), it also shows there is a significant difference between level and score ($F=118.696$; $p<0.001$). A significant interaction between level and status has also been identified ($F=23.823$; $p<0.001$) which will be considered further.

In order to analyse the significance of the increase in score for each level independently, one-way analyses of variance were carried out for each level.

There were high significant differences between scores obtained in status 1 and status 2 identified for tutorial 1;

Level 1 - (F=109.1; p<0.001).

Level 2 - (F=25.971; p<0.001).

Level 3 - (H=33.617; p<0.001).

Level 4 - (H=24.370; p<0.001).

Level 5 - No significant difference

Level 5 consisted of postgraduates and staff with varying levels of knowledge. The group was divided further to analyse the participants with limited previous knowledge of the adult pelvis (5a) independently from those with prior knowledge (5b) to account for participants with different levels of knowledge.

As seen from Figure 26 level 5b participant score between status 1 and 2 with have remained relatively constant. As they are scoring high in status 1, there is little room for improvement. Level 5a however show a larger increase in score between status 1 and 2, suggesting they have learned from tutorial 1.

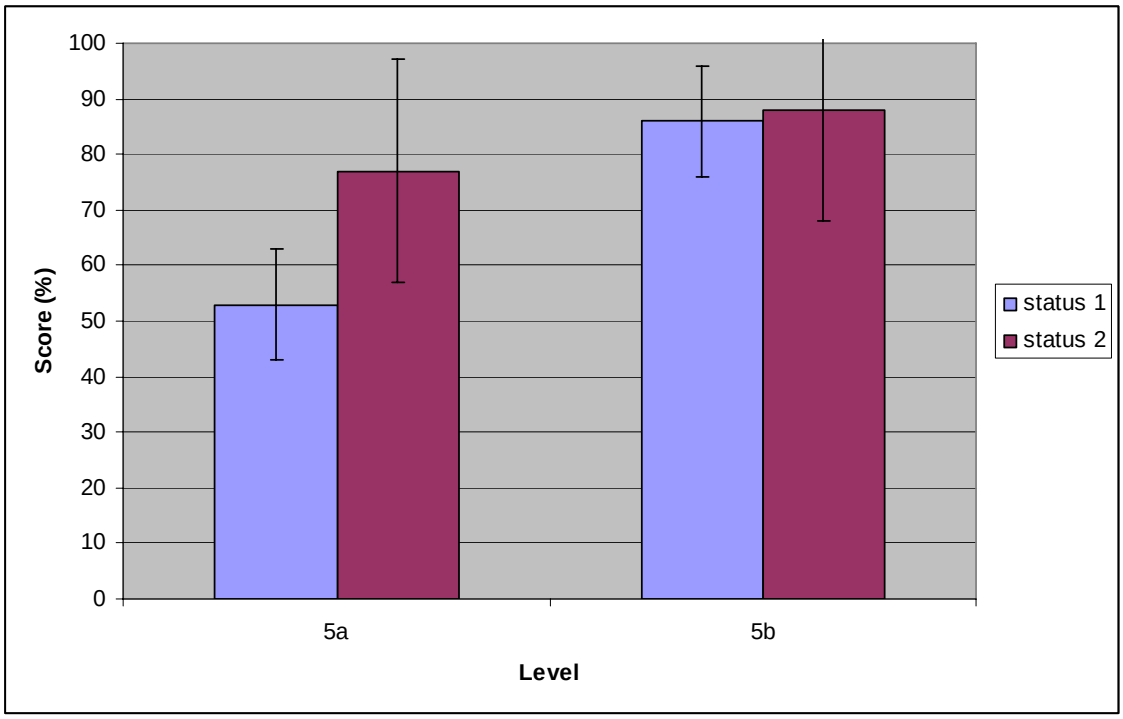

Figure 26: Tutorial 1 scores for level 5a and 5b for status 1 and status 2.

One-way analyses of variance were carried out and found 5a to have a significant difference in scores between status 1 and 2, but no significant differences were found for 5b;

Level 5a - ($F=9.007$; $p<0.01$).

Level 5b - No significant difference

With the exception of level 5b the results above have supported the initial proposition that the tutorials had a positive effect on score.

Tutorial 1 was found to be successful overall, test scores increased between status 1 and 2 for levels 1-4 and 5b (Figure 25) which were found to be significant ($p<0.001$). Participants with little previous knowledge (level 1 - 3) of the skeleton (level 1 - 3 and 5a) were expected to score low in status 1, and show the largest increase between status 1 and 2 compared to participants who had knowledge of the skeleton prior to November 2007. Level 4 and 5a were expected to score high in status 1 leaving little room for improvement as their standards were already high. It was therefore proposed that neither level would increase significantly between status 1 and 2.

Level 4 demonstrated an increase in score between statuses (Figure 25) which, following statistical analysis, was proved a significant difference. This suggests although level 4 had high scores in status 1, they still improved after completing the online module.

The analyses of variance carried out above calculated the overall response for tutorial 1 (status 1 vs. status 2) for each level. Test 1 was then divided into the individual questions of the test in order to address specific areas within the tutorials.

In order to avoid participants guessing answers to questions, they were given the option to choose don't know and strongly directed to

choose this option when appropriate. If the online tutorials had a positive effect on results, the number of "don't knows" would decrease. However this was not always the case, as seen in some questions discussed below. In these cases, not all levels improved, which may indicate areas of the tutorials which may require to be addressed to improve their appropriateness.

Question 1 - Yes / No

"*Is the skeleton in the anatomical position?*"

Possible answers: yes, **no** or don't know.

Table 5 indicates the results from question 1, test 1 at each level for status 1 (before completing tutorial 1) and status 2 (after completing tutorial 1). It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 for all participants.

The number of correct answers has not increased for some levels (1, 2 and 5a), but rather the number of wrong answers has increased, suggesting a negative effect (i.e. participants have not learned the content of the question from tutorial 1). A positive result can be seen for level 3, as the number of correct answers has increased. Level 4 and 5b remain unchanged between status 1 and 2.

Level	**Status 1**			**Status 2**		
	Correct ("no")	**Wrong ("yes")**	**Don't know**	**Correct ("no")**	**Wrong ("yes")**	**Don't know**
1	20	2	7	15	14	0
2	8	3	2	8	4	1
3	11	4	8	23	0	0
4	19	0	0	19	0	0
5a	1	2	1	2	2	0
5b	14	0	0	14	0	0
Total	**73**	**11**	**18**	**81**	**20**	**1**

Table 5: Results for question 1 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 6).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	0.72	ns	9.00	0.01	7	0.01
2	0.00	ns	0.14	ns	0.34	ns
3	4.34	0.05	5.00	0.05	4.24	0.05
4	0.00	ns	0.00	ns	0.00	ns
5a	3.34	ns	0.00	ns	1.00	ns
5b	0.00	ns	0.00	ns	0.00	ns
All Participants	**0.42**	**ns**	**2.62**	**ns**	**15.22**	**0.001**

Table 6: Chi-squared for difference between status 1 and status 2.

Table 2 demonstrates a significant difference in the total number of don't knows in status 1 compared to status 2. If the tutorial had a positive effect on participants, a significant difference in correct answers would also be apparent. However, this is not the case, no significant differences have been observed for the total number of correct answers between status 1 and 2 in addition to no significant difference in the wrong answers between status 1 and 2. Although a significant difference has been observed in the number of "don't knows" answered in status 1 compared to status 2, as there is no significant increase in correct or wrong answers there is no evidence to suggest tutorial 1 has assisted participants in answering question 1 correctly.

In status 1, levels 1-3 showed no (or little) prior knowledge of anatomical terminology (Table 5). Following the tutorial it was expected that participants would learn the particular term in question

and the number of correct answers would show a significant increase and the number of don't knows would drop to 0. This however was not the case for level 1. Chi-squared values were calculated and a significant difference in the number of wrong answers between status 1 and 2, which is indicative of these participants not learning the content of this particular question. Level 2 also showed no significant differences between status 1 and 2, suggesting these participants did not learn the content of question 1 from tutorial 1.

Level 3 was the exception in this case as each participant has answered correctly in status 2 (Table 5). However, credit in this case cannot be given solely to the online course, due to level 3 participants completing a module on the introduction to anatomy which focuses on basic anatomical terminology. Therefore a complex assessment as illustrated by this question may benefit from more intensive instruction.

Levels 4- 5b show no significant differences between status 1 and 2 for correct, wrong and "don't knows" answers. Table 5 shows almost 100% correct answers in status 1, leaving no room for improvement. This was expected as these individuals had knowledge of anatomical terminology (the area being tested in question 1) prior to status 1.

There is one reference to the anatomical position within the tutorial which was present in the anatomical terminology page, which was not a compulsory feature to view. Participants not accessing this tool would not learn this information.

Although participants without previous knowledge of the skeleton did not show learning in this particular area, learning anatomical terminology was not the aim of this project. In the future, should the course be developed further, introductory section teaching

participants basic anatomical terminology would be included which participants would be tested on before continuing with learning the osteology. Examples of terminology in a side tutorial might prove to be of assistance.

Question 2 - True / False

"The innominate (also known as the hip bone or os coxae) can be palpated through skin and soft tissues?"

Possible answers: **true**, false or don't know.

Table 7 indicates the results from question 2, test 1 at each level for status 1 and status 2. The overall number of "don't knows" has decreased between status 1 and status 2 for all participants.

Positive results are observed for levels 1 - 4 as the number of correct answers has increased between status 1 and 2. 5 a and 5b remain unchanged and have answered 100% correctly for both status 1 and 2.

Level	**Status 1**			**Status 2**		
	Correct ("true")	**Wrong ("false")**	**Don't know**	**Correct ("no")**	**Wrong ("yes")**	**Don't know**
1	5	2	21	25	3	1
2	5	2	6	7	3	3
3	6	1	16	21	2	0
4	18	0	1	19	0	0
5a	4	0	0	4	0	0
5b	14	0	0	14	0	0
Total	**53**	**5**	**44**	**90**	**8**	**4**

Table 7: Results for question 2 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 8).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	13.34	0.001	0.20	ns	18.18	0.001
2	0.34	ns	0.20	ns	1.00	ns
3	6.42	0.05	0.34	ns	16.00	0.001
4	0.02	ns	0.00	ns	1.00	ns
5a	0.00	ns	0.00	ns	0.00	ns
5b	0.00	ns	0.00	ns	0.00	ns
All Participants	**9.58**	**0.01**	**0.70**	**ns**	**33.34**	**0.001**

Table 8: Chi-squared for difference between status 1 and status 2.

The chi-squared calculations showed a significant difference in the number of "don't knows" in status 1 compared to status 2 for all participants. The Table above indicates the tutorial has had a positive effect on the participants score as the number of correct answers has significantly increased for all participants.

Level 1 demonstrated a high significant difference between correct answers in status 1 compared to status 2, suggesting they had learned from the content. The difference in the number of "don't knows" answered was also found to significantly decease. This result further supports the view that tutorial 1 had a positive effect on level 1 participants.

Results from level 2 show an increase in correct answers, and a decrease in "don't knows" (Table 7) however none of these were found to be significant. This suggests the content questioned in question 2 may not have been understood by level 2 as their scores

did not improve significantly, however due to a small sample size this can not be confirmed.

Level 3 showed a significant difference in correct answers between status 1 and 2, suggesting these participants understood the content following completion of tutorial 1. Referring back to question 1, these participants have completed a course in the introduction to anatomy where they may have learned the content of this particular question.

As discussed earlier levels 4 and 5b were expected to show no significant differences between status 1 and 2 due to their previous knowledge of anatomy which left limited room for improvement in status 2. In addition to level 4 and 5b showing no significant differences, level 5a also demonstrated this.

There is one reference to the palpable parts of the innominate on the skeleton; this was using the 3D proof of concept animation. As correct answers increased overall, this feature was successful for teaching the palpable parts of the skeleton. Evaluation on student thoughts of the proof of concept shall be considered in (evaluation section).

Question 3 - multiple choice

"Which of these contribute to the pelvic girdle?"

Possible answers: **right and left innominates**, **sacrum, coccyx**, lumbar vertebrae 1-4, right and left femora and don't know.

Participants gained one mark for each correct answer, however, for analysis, participants not obtaining full marks have been marked as wrong. This method may highlight areas where participants do not understand the content of the question fully.

Table 9 indicates the results from question 3, test 1 at each level for status 1 and status 2. It can be seen in Table 5 the number of "don't knows" has decreased between status 1 and 2 for all participants.
The number of correct answers has also increased for all participants. For levels 2 - 5b the number of wrong answers has decreased, however level 1 shows an increase in this area.

Level	**Status 1**			**Status 2**		
	Correct (3/3)	**Wrong (0,1,2/3)**	**Don't know**	**Correct (3/3)**	**Wrong (0,1,2/3)**	**Don't know**
1	1	11	17	16	12	1
2	0	3	11	9	1	3
3	2	9	12	17	6	0
4	8	11	0	15	3	0
5a	2	2	0	3	1	0
5b	7	7	0	9	5	0
Total	**20**	**50**	**47**	**83**	**30**	**5**

Table 9: Results for question 3 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 10).

	Correct		**Wrong**		**Don't know**	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	13.24	0.001	0.04	ns	14.22	0.001
2	9.00	0.01	1	ns	4.58	0.05
3	11.84	0.001	0.60	ns	12.00	0.001
4	2.14	ns	4.58	0.05	0.00	ns
5a	0.20	ns	0.34	ns	0.00	ns
5b	0.26	ns	0.34	ns	0.00	ns
Total	**38.54**	**0.001**	**5.00**	**0.01**	**33.92**	**0.001**

Table 10: Chi-squared for difference between status 1 and status 2.

The chi-squared calculations in Table 6 found a significant difference in the number of "don't knows" in status 1 compared to status 2 for all participants. Table 6 indicates the tutorial has had a positive effect on the participants' score as the number of correct answers has increased significantly for all participants.

Levels 1-3 show significant differences between status 1 and 2 “correct” and “don’t knows” answered. Level 2 did not show as high a significant difference as level 1 and 3 for the number of "don't knows" answered between status 1 and 2 however, this could be due to sample size. Although level 1 showed an increase in “wrong” answers (Table 9), this was not found to be significant.

Although level 3 showed a significant difference in "correct" and "don’t know" answers between status 1 and 2, referring back to previous questions, these participants have completed a course in the introduction to anatomy where they may have learned the content of this particular question.

As discussed earlier levels 4 and 5b were expected to show no significant differences between status 1 and 2 due to their previous knowledge of anatomy which left limited room for improvement in status 2. In addition to level 4 and 5b showing no significant differences, level 5a also demonstrated this.

This question refers to a colour 2D image which illustrates the components of the pelvic girdle. The above results suggest this feature was a successful teaching element.

Question 4 - Drag and drop

"Drag these labels to their bony landmark"

This drag and drop question used an image of the left innominate. Participants were asked to label the greater sciatic notch, Ischial tuberosity, Ischial spine and the acetabulum.

Participants gained one mark for each correct answer, however for the purpose of analysis, participants not obtaining full marks have been marked as "wrong." This method may highlight areas where participants do not understand the content fully.

Table 11 indicates the results from question 4, test 1 at each level for status 1 and status 2. Level 1- 5a show an increase in correct answers whilst the number of don't knows decreased. Little changes are observed for the number of wrong answers in status 1 compared to status 2 for levels 1 - 3. Level 5b show no change between status 1 and 2.

Level	**Status 1**			**Status 2**		
	Correct (4/4)	**Wrong (0,1,2,3/4)**	**Don't know**	**Correct (4/4)**	**Wrong (0,1,23/4)**	**Don't know**
1	0	14	15	7	15	7
2	1	4	8	6	4	3
3	0	9	14	17	6	0
4	6	12	1	17	1	1
5a	2	2	0	3	1	0
5b	13	1	0	13	1	0
Total	**22**	**42**	**38**	**63**	**28**	**11**

Table 11: Results for question 4 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 12).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	7.00	0.01	0.04	ns	2.90	ns
2	3.58	ns	0.00	ns	2.28	ns
3	17.00	0.001	0.60	ns	14.00	0.001
4	5.26	0.05	9.30	0.01	0.00	ns
5a	0.20	ns	0.34	ns	0.00	ns
5b	0.00	ns	0.00	ns	0.00	ns
Total	**19.78**	**0.001**	**2.8**	**ns**	**14.88**	**0.001**

Table 12: Chi-squared for difference between status 1 and status 2.

The number of correct answers for all levels increased significantly whilst the number of "don't knows" decreased significantly suggesting that overall the tutorial had a positive effect on results.

Level 1 showed a positive significant difference in the number of correct answers between status 1 and 2. This indicates these participants improved their knowledge of the content of this particular question. However, Table 11 shows a high number of wrong answers in status 1 which has not changed in status 2, suggesting no improvement. Therefore although a significant difference in correct answers was observed, the consistent number of wrong answers suggests the content was not fully understood by this level.

As level 2 was a small sample, their differing results in status 1 leaves little room for significant improvement by status 2. No conclusions can be drawn from this particular group from the results obtained from question 4.

Level 3 show the highest significant difference between correct answers in status 1 and 2. Referring back to previous questions, these participants have completed a course in the introduction to

anatomy where they may have learned the content of this particular question.

A significant increase in correct answers has been demonstrated by level 4. The number of wrong answers has decreased significantly between status 1 and 2. These results suggest the tutorials have had a positive effect on level 4. It was expected that these participants would score high in status 1, however in this case their scores appear to be improved following the online tutorials. However, between status 1 and 2, level 4 participants also completed modules in gross anatomy and human osteology, which may have led to this significant improvement.

As discussed earlier level 5b were expected to show no significant differences between status 1 and 2 due to high scores in status 1 (Table 11). This was also the case for 5a, and no significant differences were observed in these cases.

This particular question refers to a number of areas within tutorial 1. The majority are explained using 2D images and text. However, some of these features are represented in a drag and drop feature which aims to assist participants learning these features. The content of this question could be better addressed in 3D format; therefore this could be suggested in the future.

Question 5 - Multiple choice

"Define the following joints (sacroiliac, pubic symphysis, hip joint, articulation between the 5th lumbar vertebra and the sacrum)"

Possible answers: cartilaginous, synovial or mixed and don't know.

Participants gained one mark for each correct answer, however, for analysis, participants not obtaining full marks have been marked as

wrong. This method may highlight areas which participants did not understand the content fully.

Table 13 indicates the results from question 5, test 1 at each level for status 1 and status 2. A large drop in don't know answers can be observed in Table 9 Overall the number of correct answers has increased by 6, however the number of wrong answers has also increased suggesting the tutorials have had little effect on status.

Level 1-3 show an increase in wrong answers between status 1 and 2, whilst little improvement can be seen by the number of correct answers. Level 4 shows a small increase in correct answers as did level 5b. Level 5a remains constant, showing no improvements or weaknesses.

Level	**Status 1**			**Status 2**		
	Correct (4/4)	**Wrong (0,1,2,3/4)**	**Don't know**	**Correct (4/4)**	**Wrong (0,1,23/4)**	**Don't know**
1	0	18	11	1	24	4
2	0	6	7	0	9	4
3	0	16	7	1	22	0
4	0	18	1	3	16	0
5a	0	4	0	0	4	0
5b	0	14	0	1	13	0
Total	**0**	**76**	**26**	**6**	**88**	**8**

Table 13: Results for question 5 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 14).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	1	ns	0.86	ns	3.26	ns
2	0	ns	0.60	ns	0.82	ns
3	1	ns	0.94	ns	7	0.01
4	3	ns	0.12	ns	13.24	0.001
5a	0	ns	0	ns	0	ns
5b	1	ns	0.04	ns	13	0.001
Total	**6**	**0.05**	**0.88**	**ns**	**9.52**	**0.01**

Table 14: Chi-squared for difference between status 1 and status 2.

A significant decrease in "don't knows" can be observed for all participants. A significant increase of correct answers has also been observed. Referring back to Table 9 the increase in correct answers is by 6 participants, less than the increase of wrong answers which was found to be not significant. Therefore this suggests the content of the question was not fully understood after completing the online tutorials as no improvements were observed or the information elicits a variable response.

The information in Table 13 did not take into consideration the participants gaining 1-3 marks out of 4. These participants were marked as wrong as they did not display full knowledge of the entire question (by not gaining full marks in status 2). Figures 27-33 below indicate the actual results obtained for each level between status 1 and 2 showing participants did improve following completion of the online material, there was just a low number of participants obtaining full marks.

Figure 27 shows the individual answers for question 5 for all participants. Overall, the number of participants gaining no marks or

stating "don't know" in status 1 has dropped. The number of participants obtaining 1-4 marks has also increased by status 2.

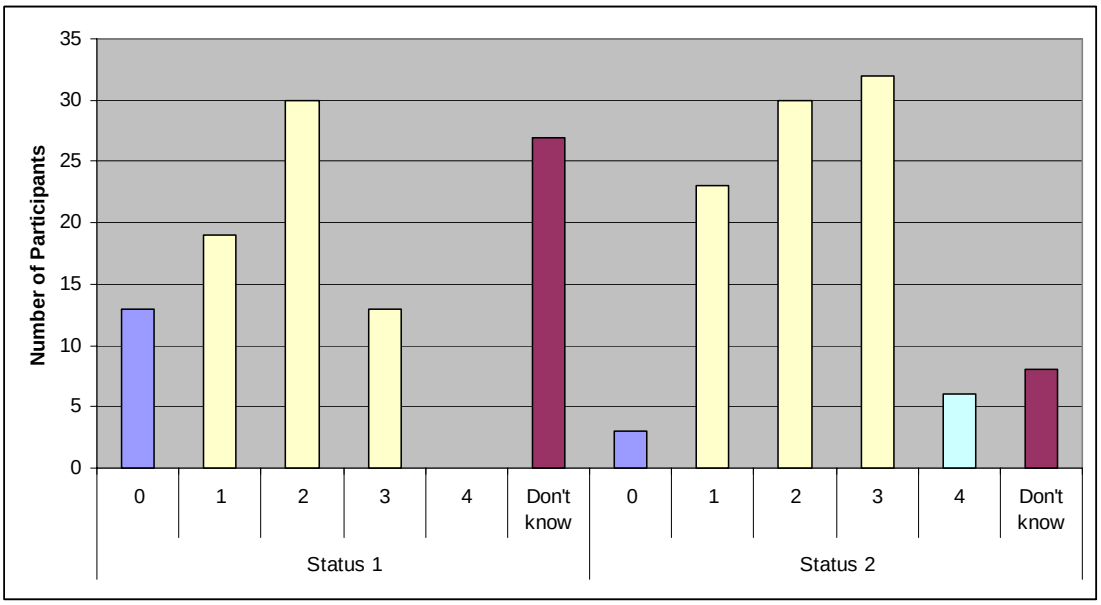

Figure 27: Actual answers for question 5 for all participants.

Figure 28 shows the individual answers for level 1 for question 5. A decrease in the number of "don't knows" answered between status 1 and 2 is observed. The number of participants gaining no marks has also decreased between status 1 and 2. The number of participants gaining between 1 and 4 marks has increased overall.

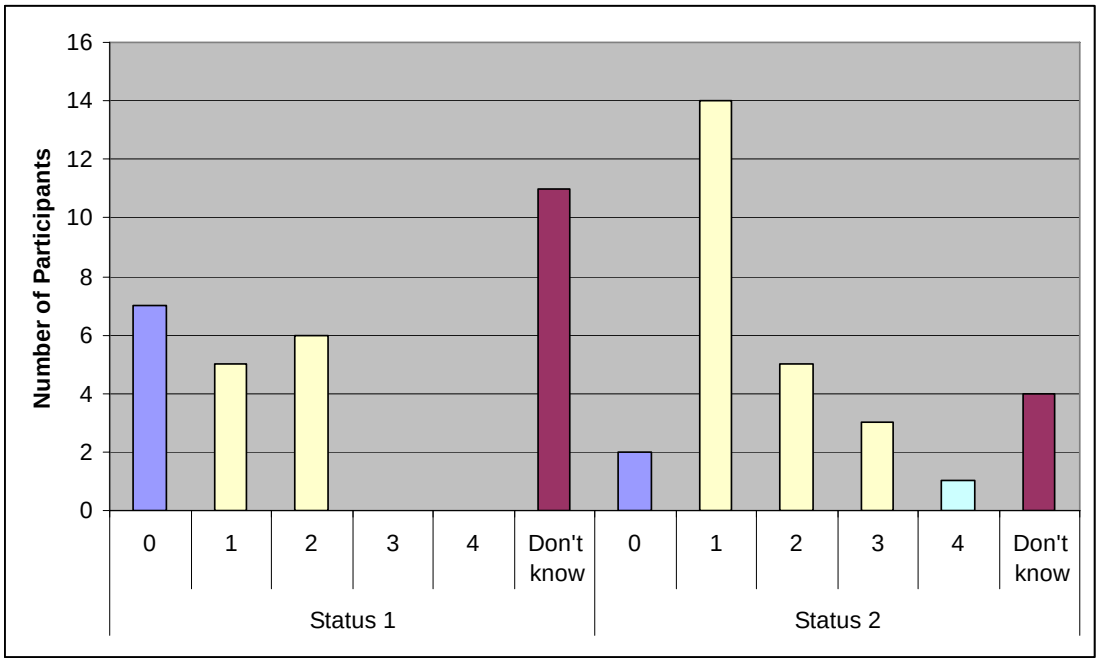

Figure 28: Actual answers for question 5 for level 1.

Figure 29 shows the individual answers for level 2 for question 5. A decrease in the number of "don't knows" answered between status 1 and 2 is observed. The number of participants gaining no marks has also decreased between status 1 and 2. The number of participants gaining between 1 and 3 marks has increased overall.

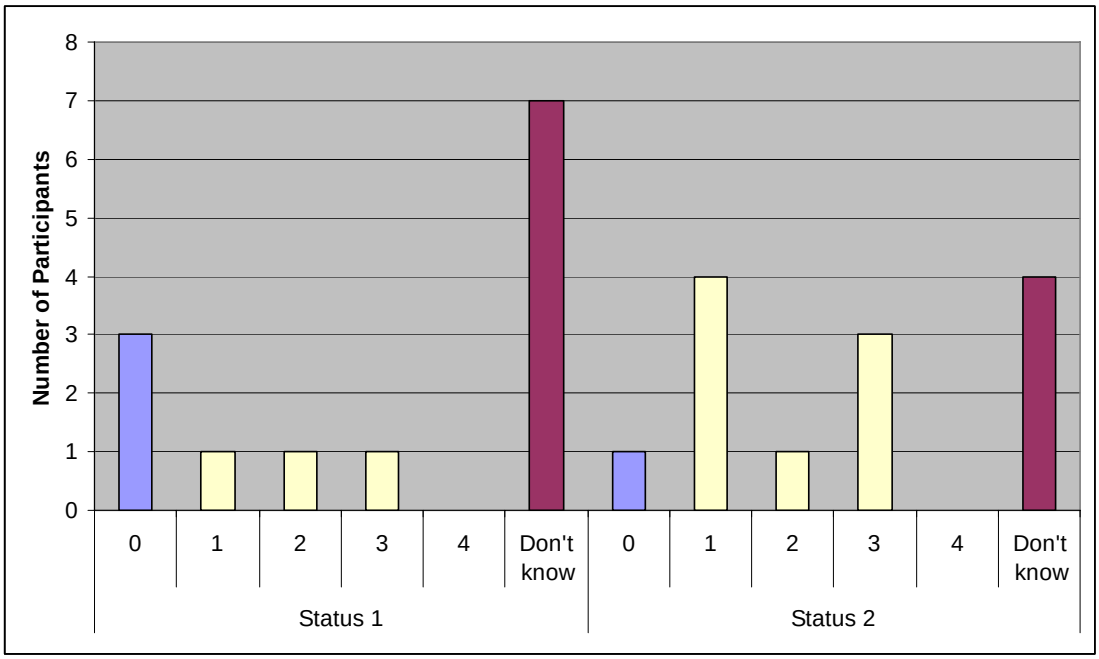

Figure 29: Actual answers for question 5 for level 2.

Figure 30 shows the individual answers for level 3 for question 5. A decrease in the number of "don't knows" answered between status 1 and 2 is observed. The number of participants gaining no marks also decreased between status 1 and 2. The number of participants gaining between 1 and 4 marks increased overall.

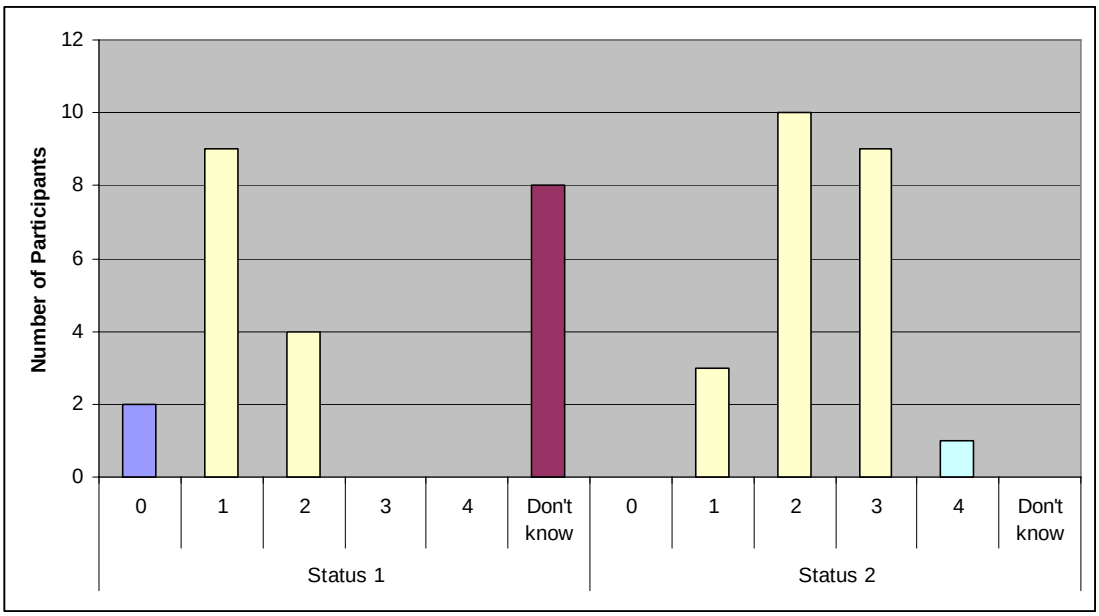

Figure 30: Actual answers for question 5 for level 3.

Figure 31 shows the individual answers for level 4 for question 5. The number of participants gaining no marks or stating "don't know" in status 1 has dropped to 0. The number of participants gaining between 1 and 4 marks has increased overall.

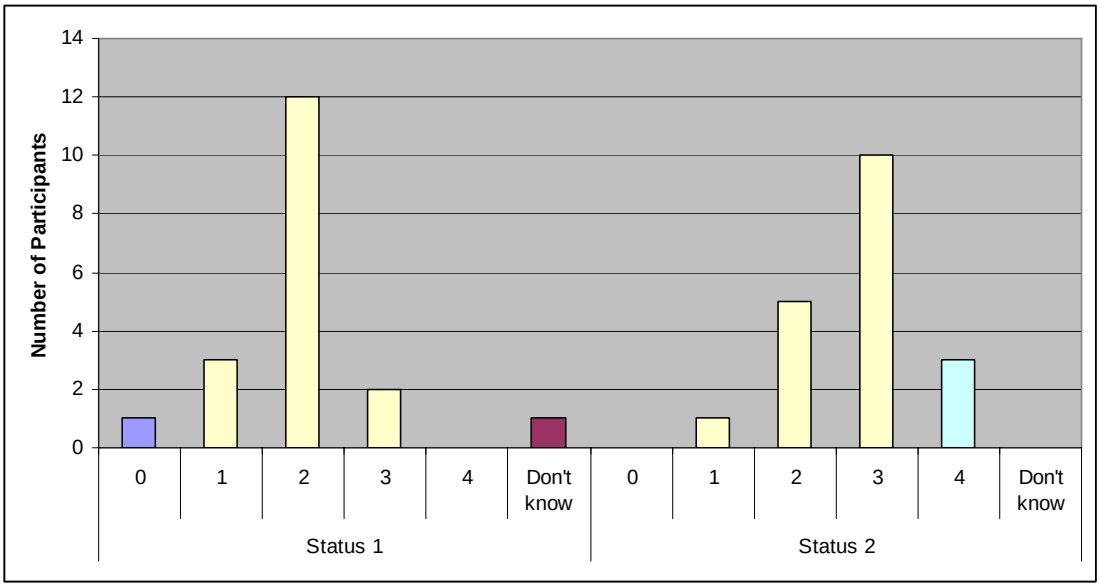

Figure 31: Actual answers for question 5 for level 4.

Figure 32 shows the individual answers for level 5a for question 5. A higher number of participants obtained higher marks for question 5 after completing tutorial 1 (status 2).

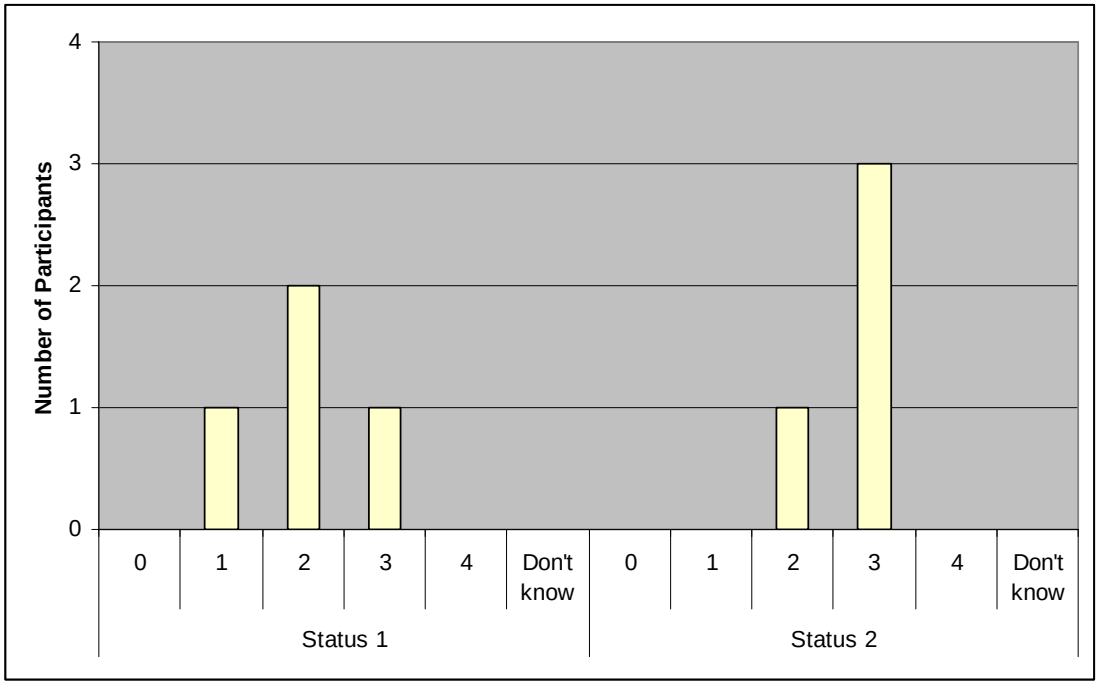

Figure 32: Actual answers for question 5 for level 5a.

Figure 33 shows the individual answers for level 5b for question 5. Results between status 1 and 2 remain constant for this particular question. No major improvements or weaknesses are observed.

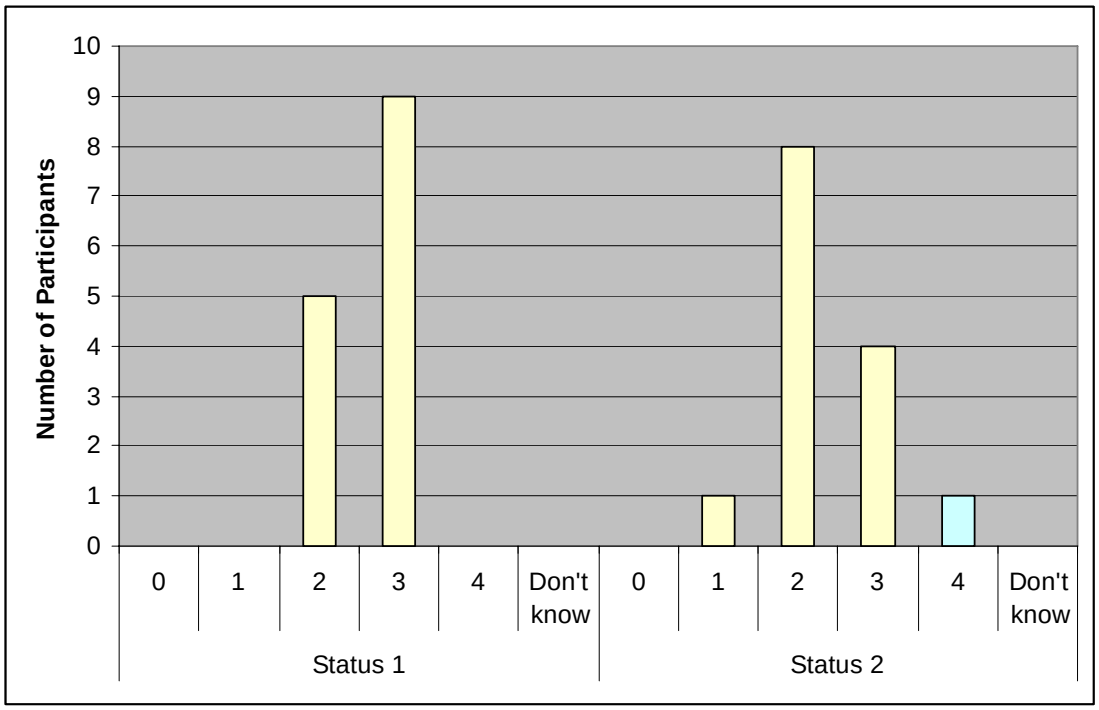

Figure 33: Actual answers for question 5 for level 5b.

Although the chi-squared calculations suggested participants did not learn the full content of this particular question following completion of the module, after observing individual answers (Figures 27-33), it

is apparent that participants were learning some of the content, but not enough to gain full marks.

This particular question is addressed within the text of the tutorial. There is no interactivity teaching these features, which may require readdressing should the project develop. Participants were not expected to know the different types of joints; however these words were available in the glossary. Linking the glossary to these terms within the tutorial may also benefit the understanding of the question for participants in the future.

Question 6 - Drag and drop

"Drag these labels to their site on the right innominate"

This drag and drop question used an image of the right innominate. Participants were asked to label the pubic symphysis, sacroiliac joint and attachment for the iliacus muscle.

Participants gained one mark for each correct answer, however, for analysis, participants not obtaining full marks have been marked as "wrong." This method may highlight areas in which participants do not understand the content fully.

Table 15 indicates the results from question 6, test 1 at each level for status 1 and status 2. Table 15 shows an increase in the number of correct answers between status 1 and 2 for levels 1-4, and all participants together. A decrease in "don’t knows" answered between status 1 and 2 has decreased for levels 1-4. These results suggest the tutorials had a positive effect on status scores.

Level	Status 1			Status 2		
	Correct (3/3)	Wrong (0,1,2/3)	Don't know	Correct (3/3)	Wrong (0,1,2/3)	Don't know
1	4	8	17	16	7	6
2	3	3	7	4	5	4
3	1	8	14	23	0	0
4	17	2	0	19	0	0
5a	3	1	0	4	0	0
5b	14	0	0	14	0	0
Total	**42**	**22**	**38**	**80**	**12**	**10**

Table 15 : Results for question 6 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 16).

	Correct		Wrong		Don't know	
Level	Chi-square	p	Chi-square	p	Chi-square	p
1	7.2	0.01	0.06	ns	5.26	0.05
2	0.14	ns	0.5	ns	0.82	ns
3	20.16	0.001	8	0.01	14	0.001
4	0.12	ns	2	ns	0	ns
5a	0.14	ns	1	ns	0	ns
5b	0	ns	0	ns	0	ns
Total	**11.84**	**0.001**	**2.94**	**ns**	**16.34**	**0.001**

Table 16: Chi-squared for difference between status 1 and status 2.

A highly significant increase in correct answers between status 1 and 2 has been demonstrated by all participants. This increase suggests the tutorials have had a significant influence on status score. A significant decrease in "don't knows" between status 1 and 2 for all participants has also been observed. This further supports the theory that the tutorials have had a positive influence on status score.

Level 1 follows the same pattern as all participants together suggesting these participants learned the content from the online tutorials.

Although level 2 shows an increase in correct answers and decrease in "don’t knows" between status 1 and 2 in Table 15 no significant differences were observed, this may be due to sample size.

Level 3 show the highest significant difference between status 1 and 2 correct answers and “don’t knows”. Referring back to previous questions, these participants have completed a course in the introduction to anatomy where they may have learned the content of this particular question.

As discussed earlier levels 4 and 5b were expected to show no significant differences between status 1 and 2 due to their previous knowledge of anatomy which left limited room for improvement in status 2. In addition to level 4 and 5b showing no significant differences, level 5a also demonstrated this.

This particular question refers to a number of areas within tutorial 1. The majority are explained using 2D images and text. However, some of these features are represented in a drag and drop activity which aims to assist participants learning these features. As participant scores improved in this particular question, it can be suggested that the method for explaining these features was successful.

Question 7 - Fill in the Blank

*"The right innominate articulates with the **sacrum** posteriorly and the **left** innominate anteriorly."*

Participants gained one mark for each correct answer, however, for analysis, participants not obtaining full marks have been marked as "wrong." This method may highlight areas in which participants do not understand the content fully.

Table 17 indicates the results from question 7, test 1 at each level for status 1 and status 2. Overall, the number of correct answers has increased, the number of wrong answers and "don't knows" have decreased between status 1 and 2.

Level 1 and 2 however show a relatively high number of don't knows in status 1 and 2 with little changes in correct and wrong answers suggesting the participants did not learn the content required to answer the question correctly. Level 3 and 4 show improvement between status 1 and 2, whilst level 5a and b show little change in answers between status 1 and 2.

Level	**Status 1**			**Status 2**		
	Correct (2/2)	**Wrong (0,1/2)**	**Don't know**	**Correct (2/2)**	**Wrong (0,1/2)**	**Don't know**
1	0	0	29	1	3	25
2	0	2	11	3	0	10
3	0	1	22	15	3	5
4	11	6	2	18	1	0
5a	2	1	1	2	2	0
5b	13	1	0	14	0	0
Total	**26**	**11**	**65**	**53**	**9**	**40**

Table 17: Results for question 7 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 18).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	1	ns	3	ns	0.3	ns
2	3	ns	2	ns	0.04	ns
3	15	0.001	1	ns	10.7	0.01
4	1.68	ns	3.58	ns	2	ns
5a	0	ns	0.34	ns	1	ns
5b	0.04	ns	1	ns	0	ns
Total	**9.22**	**0.01**	**0.2**	**ns**	**5.96**	**0.05**

Table 18: Chi-squared results for difference between status 1 and status 2.

An improvement has been observed for the total number of participants by the number of correct answers increasing significantly and the number of "don't knows" answered between status 1 and 2 decreasing significantly.

Levels 1 and 2 show no significant differences between the answers in status 1 and 2 (Table 17). This suggests they have not learned the content of the question during the completion of the online tutorials.

Level 3 show the only significant differences between status 1 and 2 suggesting an improvement after completing the online tutorial. Referring back to previous questions, these participants have completed a course in the introduction to anatomy where they may have learned the content of this particular question.

As discussed earlier levels 4 and 5b were expected to show no significant differences between status 1 and 2 due to their previous

knowledge of anatomy which left limited room for improvement in status 2. In addition to level 4 and 5b showing no significant differences, level 5a also demonstrated this.

As this question was a fill in the blank question participants were given no options for answers. This type of question is particularly problematic as wrong answers result if wrong spellings occur and often there are two or more accurate answers, however the question is looking for one answer specifically. In this case there were few participants who spelled the answers wrong. The question however did rely on the basic knowledge of anatomical terminology, which, from question 1, was not fully understood by level 1 and 2 participants after tutorial 1.

Question 8 - Drag and drop

"Drag the following muscles to their attachment"

This drag and drop question used images in which participants were asked to label muscle attachments on the left innominate including gluteus maximus, gluteus medius and gluteus minimus.

Participants gained one mark for each correct answer, however, for analysis, participants not obtaining full marks have been marked as "wrong." This method may highlight areas where participants did not understand the content fully.

Table 19 indicates the results from question 8, test 1 at each level for status 1 and status 2. Overall, the number of correct answers increased the number of wrong answers and "don't knows" decreased between status 1 and 2 for all participants (Table 19).

Level 1 and 2 however show a relatively high number of "don't knows" in status 1 and 2 with little changes in correct and wrong answers suggesting the participants did not learn the content required to answer the question. Level 3, 4 and 5b show improvement between status 1 and 2, whilst level 5a's results remain unchanged.

Level	**Status 1**			**Status 2**		
	Correct (3/3)	**Wrong (0,1,2/3)**	**Don't know**	**Correct (3/3)**	**Wrong (0,1,2/3)**	**Don't know**
1	0	2	31	5	2	26
2	0	1	16	3	2	12
3	1	3	22	12	6	8
4	7	5	9	15	3	3
5a	1	3	0	1	3	0
5b	7	6	1	12	2	0
Total	**16**	**20**	**79**	**48**	**18**	**49**

Table 19: Results for question 8 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 20).

	Correct		**Wrong**		**Don't know**	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	5	0.05	2	ns	0.46	ns
2	3	ns	0.34	ns	0.66	ns
3	9.3	0.01	1	ns	6.54	0.05
4	2.9	ns	0.5	ns	3	ns
5a	1	ns	3	ns	0	ns
5b	1.32	ns	2	ns	1	ns
Total	**16**	**0.001**	**0.1**	**ns**	**7.04**	**0.01**

Table 20: Chi-squared results for difference between status 1 and status 2.

A significant improvement was observed for the total number of participants by the number of correct answers and the number of "don’t knows" answered between status 1 and 2. This suggests the participants have understood the content of the question.

Level 1 show a significant difference between the number of correct answers in status 1 compared to status 2. This suggests the tutorial has had a positive effect on this level. However, referring back to Table 15 only 5 participants improved whilst the number of don't knows answered dropped by 5. As there are 33 participants in level 1, 5 have improved, whilst the remaining participants show no improvement or weaknesses. This suggests the majority of these participants did not learn the content of the question. Level 2 shows similar results to level 1, however no significant differences were observed.

Level 3 show significant differences between status 1 and 2 correct answers and "don't knows" suggesting an improvement after completing the online tutorial. Referring back to previous questions, these participants have completed a course in the introduction to anatomy where they may have learned the content of this particular question.

Level 4 show no significant differences between status 1 and 2. As initial scores were not high in status 1 (Table 19) it would be expected that this level would improve significantly following completion of tutorial 1 as they have also completed a course in gross anatomy in addition to the online module between status 1 and 2. However, these results suggest these participants did not understand this particular area fully.

Level 5a results remain unchanged between status 1 and 2 (Table 19) therefore no significant difference were observed. This small sample group have obtained a low number of correct answers in status 1, and scores have not improved by status 2 suggesting the content of the question was not understood.

Level 5b show no significant differences between status 1 and 2. As initial scores were not high in status 1, it would be expected that this level would improve significantly following completion of tutorial 1 as they have a background in anatomy and the online tutorial would have been a revision tool. However, these results suggest these participants did not understand this particular area fully.

As individual levels were not improving, it can be suggested that this particular area should be readdressed if the module was to progress. There was one reference to these muscle attachments within the course which was via the glossary. Participants not utilising this tool would not pick up this piece of information. In the future, it is proposed that this question be addressed within the content of the tutorial rather than an external link.

Question 9 - Fill in the Blank

"The shape of the adult female pelvis reflects a compromise between 2 major functions ***bipedal*** *locomotion and safe parturition"*

Table 21 indicates the results from question 9, test 1 at each level for status 1 and status 2. An overall increase in correct answers and a decrease in wrong and "don't knows" answered is observed for all participants between status 1 and 2 (Table 21).

Level 1 and 2 however, show little change, with the number of "don't knows" falling and the number of correct answers increasing by 5 in

level 1 and 2 in level 2, suggesting the tutorial had little effect on score. Level 3 - 5b show a higher number of correct answers in status 2, suggesting the participants understood the content of the question.

Level	Status 1			Status 2		
	Correct	Wrong	Don't know	Correct	Wrong	Don't know
1	0	2	27	5	2	22
2	0	1	12	2	1	10
3	1	3	19	12	6	5
4	7	5	7	14	3	2
5a	1	2	1	2	1	1
5b	7	6	1	12	2	0
Total	**16**	**19**	**67**	**47**	**15**	**40**

Table 21: Results for question 9 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 22).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	5	ns	2	ns	0.51	ns
2	2	1	1	ns	0.18	ns
3	9.3	0.01	1	ns	8.16	0.01
4	2.34	ns	0.5	ns	2.78	ns
5a	0.34	ns	0.34	ns	1	ns
5b	1.32	ns	2	ns	1	ns
Total	**15.26**	**0.001**	**0.48**	**ns**	**6.82**	**0.05**

Table 22: Chi-squared results for difference between status 1 and status 2.

Overall a significant difference has been observed for the number of correct answers and the number of "don't knows" answered for all

participants. This suggests that the participants learned the content of the question during the completion of the online module.

Level 1 shows a significant difference between the number of correct answers in status 1 compared to status 2. This suggests the tutorial has had a positive effect on this level. However, referring back to Table 17 only 5 participants improved whilst the number of "don't knows" answered dropped by 5. As there are 33 participants in level 1, 5 have improved, whilst the remaining participants show no improvement or weaknesses. This suggests these participants did not learn the content of the question. Level 2 show similar results to level 1, however no significant differences are observed.

Level 3 show significant differences between status 1 and 2 correct answers and "don't knows" suggesting an improvement after completing the online tutorial. Referring back to previous questions, these participants have completed a course in the introduction to anatomy where they may have learned the content of this particular question.

Level 4 show no significant differences between status 1 and 2. As initial scores were not high in status 1, it would be expected that this level would improve significantly following completion of tutorial 1 as they have completed a course in gross anatomy in addition to the online module between status 1 and 2. However, these results suggest these participants did not understand this particular area fully.

Level 5a and 5b, also show no significant differences between the answers given in status 1 compared to status 2, suggesting these participants have not learned the content being questioned during the completion of the online module.

As this question was a fill in the blank question participants were given no options for answers. This type of question is particularly problematic as wrong answers result if wrong spellings occur and often there are two or more accurate answers, however the question is looking for one answer specifically. In this case there were few spelling mistakes which result in wrong answers. However, there were a number of participants who were marked wrongly as they did not state bipedal, but their answer was accurate (for example; efficient and upright).

This particular question is discussed briefly in the first part of tutorial 1 where the term bipedal locomotion is mentioned once within the content of the tutorial and again in the glossary page. However, although two approaches were made to discuss this term, participants did not necessarily learn it. Therefore, another approach such as looking at different types of locomotion in an animation could be suggested.

Question 10 - Multiple choice

" In development which of these fuse to create the innominate? "

Possible answers: **ilium, ischium, pubis**, trochanter and acetabulum or "don't know."

Participants gained one mark for each correct answer, however, for analysis, participants not obtaining full marks have been marked as "wrong." This method may highlight areas which participants did not understand the content fully.

Table 23 indicates the results from question 10, test 1 at each level for status 1 and status 2. The results for all the participants show an increase in correct answers between status 1 and 2 in addition to a decrease in don't knows answered between status 1 and 2. Usually

this would suggest the online tutorials had a positive effect on participants, however, an increase in wrong answers is also observed. Level 1 and 2 show similar results to this, whilst level 3 - 5b show increases in correct answers, little or no change to wrong answers and a decrease in don't knows answered between status 1 and 2.

Level	**Status 1**			**Status 2**		
	Correct	**Wrong**	**Don't know**	**Correct**	**Wrong**	**Don't know**
1	1	1	27	13	13	3
2	0	1	12	8	3	2
3	2	3	18	21	2	0
4	15	0	3	17	1	0
5a	1	3	0	2	2	0
5b	12	2	0	14	0	0
Total	**31**	**10**	**60**	**65**	**21**	**5**

Table 23: Results for question 10 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 24).

	Correct		**Wrong**		**Don't know**	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	10.28	0.01	10.28	0.01	19.2	0.001
2	8	0.01	1	ns	7.14	0.01
3	15.7	0.001	0.2	ns	18	0.001
4	0.12	ns	1	ns	3	ns
5a	0.34	ns	0.2	ns	0	ns
5b	0.16	ns	2	ns	0	ns
Total	**12.04**	**0.001**	**3.9**	**0.05**	**46.54**	**0.001**

Table 24: Chi-squared results for difference between status 1 and status 2.

The results from the chi-square above show a significant difference between the number of correct answers answered between status 1 and 2 and between the number of don't knows answered between status 1 and 2 for all participants. Together these results suggest the online material has had a positive effect on score. However, a significant difference in wrong answers has also been observed. Although this value is not as significant, it still suggests the online tutorial has not benefited some participants, causing the number of wrongs answers to increase. Further analysis into levels was undertaken.

Level 1 demonstrates the same chi-squared and significance values for correct and wrong answers. As there is an increase in both, it can be suggested that the tutorial had a positive effect on some participants, but a negative on others. It can therefore be concluded that the content of the question should be addressed again if the tutorial was to be used in the future.

Level 2 show a significant difference between the number of correct answers in status 1 compared to status 2, suggesting a positive effect. The results for the "don't knows" further supports this as there is a significant decrease between status 1 and 2. No significant difference has been observed for the number of wrong answers between status 1 and 2, therefore it can be concluded that the content of this particular question was understood by level 2.

Level 3 show significant differences between status 1 and 2 correct answers and "don't knows" suggesting an improvement after completing the online tutorial. Referring back to previous questions, these participants have completed a course in the introduction to anatomy where they may have learned the content of this particular question.

As discussed earlier levels 4 and 5b were expected to show no significant differences between status 1 and 2 due to their previous knowledge of anatomy which left limited room for improvement in status 2. In addition to level 4 and 5b showing no significant differences, level 5a also demonstrated this.

The content of this particular question will be addressed again in tutorial 2. Tutorial 1 mentioned the three bones contributing to the adult innominate briefly with respect to development, but mainly considered the adult form. Therefore it is not crucial that participants learn the content from tutorial 1, as it will be considered in more depth in tutorial 2.

Question 11 - Multiple choice

"Side this innominate "

An image of a right innominate was given, and participants were asked to choose which side of the body it came from.

Possible answers: left, **right**, don't know.

Table 25 indicates the results from question 11, test 1 at each level for status 1 and status 2. Overall, the number of correct answers has increased between status 1 and 2 and the number of "don't knows" answered has decreased for all participants, indicating the online tutorial has had a positive effect. However, a relatively high number of wrong answers for the total number of participants is observed, which has decreased by 1 between status 1 and 2. This suggests although there is a positive effect, it is not great enough to decrease the number of wrong answers.

Levels 1-4 show increases in correct answers and decreases in "don't knows", however, the drop between status 1 and 2 for wrong answers is not as large. Levels 5a and b remain constant.

Level	Status 1			Status 2		
	Correct	Wrong	Don't know	Correct	Wrong	Don't know
1	5	9	15	11	15	3
2	2	7	4	5	6	2
3	4	11	8	15	8	0
4	12	5	2	15	4	0
5a	3	1	0	3	1	0
5b	13	1	0	13	1	0
Total	**39**	**34**	**29**	**62**	**35**	**5**

Table 25: Results for question 11 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 26).

	Correct		Wrong		Don't know	
Level	Chi-square	p	Chi-square	p	Chi-square	p
1	2.26	ns	1.5	ns	8	0.01
2	1.28	ns	0.08	ns	0.66	ns
3	6.36	0.05	0.48	ns	8	0.01
4	0.34	ns	0.01	ns	2	ns
5a	0	ns	0	ns	0	ns
5b	0	ns	0	ns	0	ns
Total	**5.24**	**0.05**	**0.01**	**ns**	**16.94**	**0.001**

Table 26: Chi-squared results for difference between status 1 and status 2.

A significant difference was observed for the number of correct answers in status 1 and 2 for all participants together and in the number of "don't knows" answered. This suggests the online material has had a positive effect on answering this particular question.

No significant differences have been observed between the correct answers in status 1 and 2 for levels 1 and 2 (Table 25). These

results suggest level 1 and 2 have not learned the content questioned in question 11.

Level 3 show significant differences between status 1 and 2 correct answers and "don't knows" suggesting an improvement after completing the online tutorial. Referring back to previous questions, these participants have completed a course in the introduction to anatomy where they may have learned the content of this particular question.

As discussed earlier levels 4 and 5b were expected to show no significant differences between status 1 and 2 due to their previous knowledge of anatomy which left limited room for improvement in status 2. In addition to level 4 and 5b showing no significant differences, level 5a also demonstrated this.

Participants were not given hints to side the adult innominate. It was assumed if participants had learned the morphology of the adult innominate they would have gained the knowledge to correctly side the bone. However, this was not successful for individual levels (with the exception of level 3), therefore in the future a siding activity will be introduced onto the online tutorial.

Question 12 - True / False

"The right and left innominates form part of the axial skeleton"

Possible answers: true, **false,** don't know

Table 23 indicates the results from question 12, test 1 at each level for status 1 (before completing tutorial 1) and status 2 (after completing tutorial 1). Table 23 shows a decrease in the number of "don't knows" answered between status 1 and 2 for levels 1-4. An increase in correct answers can also be seen for these levels

suggesting the participants have learned the content. Level 5a and b remain constant.

Level	Status 1			Status 2		
	Correct	Wrong	Don't know	Correct	Wrong	Don't know
1	2	5	22	14	14	1
2	2	4	7	7	4	2
3	4	11	8	15	8	0
4	12	5	2	15	4	0
5a	3	1	0	3	1	0
5b	13	1	0	13	1	0
Total	**36**	**27**	**39**	**67**	**32**	**3**

Table 27: Results for question 12 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 28).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	9	0.01	4.26	0.05	19.17	0.001
2	2.78	ns	0	ns	2.78	ns
3	6.37	0.05	0.47	ns	8	0.01
4	0.33	ns	0.11	ns	2	ns
5a	0	ns	0	ns	0	ns
5b	0	ns	0	ns	0	ns
Total	**15.25**	**0.001**	**0.42**	**ns**	**30.86**	**0.001**

Table 28: Chi-squared results for difference between status 1 and status 2.

A significant difference has been observed for all participants in the number of correct answers answered between status 1 and 2 in addition to a significance in "don't knows" answered between status 1

and 2. These results suggest the participants have learned the content questioned in question 12. However, the number of wrong answers remains relatively high in status 2 suggesting participants may have had difficulties answering this question following the tutorial.

Level 1 showed a significant difference between the number of correct answers answered between status 1 and 2. They also showed a significant difference in the number of "don't knows" answered. These results suggest tutorial 1 gave these participants the knowledge to answer the question. However, an increase in wrong answers is also observed in Table 27 which was found to be significant. This suggests that although some participants in this level are improving, others are not.

No significant differences have been observed between the answers in status 1 and 2 for level 2 (Table 28). These results suggest level 2 have not learned the content questioned in question 11. However, due to a small sample size, this cannot be confirmed.

Level 3 show significant differences between status 1 and 2 correct answers and "don't knows" suggesting an improvement after completing the online tutorial. Referring back to previous questions, these participants have completed a course in the introduction to anatomy where they may have learned the content of this particular question.

As discussed earlier levels 4 and 5b were expected to show no significant differences between status 1 and 2 due to their previous knowledge of anatomy which left limited room for improvement in status 2. In addition to level 4 and 5b showing no significant differences, level 5a also demonstrated this.

The axial and appendicular skeleton were discussed at the beginning of tutorial 1 and not reinforced until the test. It can therefore be suggested the knowledge of basic anatomical terminology is essential for participants to learn. In the future, should the course be developed further, an introductory section teaching participants basic anatomical terminology would be included on which participants would be tested, before continuing with learning the osteology.

Question 13 - True / False

"A synovial joint can be seen above?"

A radiograph of the hip joint was used.

Possible answers: **true**, false or don't know.

Table 29 indicates the results from question 12, test 1 at each level for status 1 and status 2. High numbers of correct answers can be seen in status 1 (Table 29) whilst the number of wrong answers remains low between status 1 and 2. A decrease in don't knows is also observed. Due to the high number of correct answers between all levels in status 1, it is suggested that the majority of participants knew this particular information prior to status 1.

Level	**Status 1**			**Status 2**		
	Correct	**Wrong**	**Don't know**	**Correct**	**Wrong**	**Don't know**
1	20	2	7	25	2	2
2	7	0	6	9	1	3
3	16	2	5	21	2	0
4	18	1	0	19	0	0
5a	4	0	0	4	0	0
5b	14	0	0	14	0	0
Total	**79**	**5**	**18**	**92**	**5**	**5**

Table 29: Results for question 13 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 30).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	0.56	ns	0	ns	2.78	ns
2	0.25	ns	1	ns	1	ns
3	0.68	ns	0	ns	5	0.05
4	0.03	ns	1	ns	0	ns
5a	0	ns	0	ns	0	ns
5b	0	ns	0	ns	0	ns
Total	**0.99**	**ns**	**0**	**ns**	**7.35**	**0.01**

Table 30: Chi-squared results for difference between status 1 and status 2.

A significant decrease in the number of "don't knows" can be observed for all participants and level 3. However there is no significant difference between any other answers for any other level.

Due to the high number of correct answers for all levels in status 1, there was little room for improvement. Table 29 shows an increase in correct answers between status 1 and 2 for all levels (except 5a and b), but these are not significant differences. It is therefore determined that the majority of participants had prior knowledge of this particular information.

Question 14 - Multiple choice

"The fusing epiphysis present on the iliac crest suggests..." Possible answers: **it is juvenile**, it is adult or don't know.

Table 31 indicates the results from question 14, test 1 at each level for status 1 and status 2. An increase in correct and wrong answers

for participants together is observed in Table 31. A decrease in "don't knows" answered is also observed for all participants between status 1 and 2.

Level 1-4 show similar results to all participants together. 5a show an improvement between status 1 and 2. 5b, have 100% correct answers in status 1 and by status 2, one participant chose don't know.

Level	**Status 1**			**Status 2**		
	Correct	**Wrong**	**Don't know**	**Correct**	**Wrong**	**Don't know**
1	6	4	19	11	14	3
2	5	2	6	6	5	2
3	4	8	11	13	9	1
4	13	4	2	14	5	0
5a	2	1	1	4	0	0
5b	14	0	0	13	0	1
Total	**44**	**19**	**39**	**61**	**33**	**7**

Table 31: Results for question 14 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 32).

	Correct		**Wrong**		**Don't know**	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	1.47	ns	5.56	0.05	11.64	0.001
2	0.09	ns	1.29	ns	2	ns
3	4.76	0.05	0.06	ns	8.33	0.01
4	0.07	ns	0.11	ns	2	ns
5a	0.67	ns	1	ns	1	ns
5b	0.04	ns	0	ns	1	ns
Total	**2.75**	**ns**	**3.77**	**ns**	**22.26**	**0.001**

Table 32: Chi-squared results for difference between status 1 and status 2.

No significant differences have been observed in the number of correct or wrong answers answered between status 1 and 2 for all participants together. Although there is a significant decrease in "don't knows", there is no evidence to suggest this is a positive decrease (as correct answers have not increased significantly) or a negative decrease (as wrong answers have not increased significantly). These results suggest the content assessed in question 14 has not been fully understood following completion of the online module.

From Table 32 it can be seen that there are no significant differences observed between answers in status 1 and status 2 with the exception of level 1 and level 3. Results from level 2, 4 and 5b demonstrate that these levels have not acquired the knowledge during the completion of tutorial 1 to answer the question correctly.

Significant increases were found for correct and wrong answers between status 1 and 2 for level 1. This suggests participants have gained false confidence.

Level 3 show significant differences between status 1 and 2 correct answers and "don't knows" suggesting an improvement after completing the online tutorial. Referring back to previous questions, these participants have completed a course in the introduction to anatomy where they may have learned the content of this particular question.

Level 5a have gained 100% correct answers in status 2, suggesting the online tutorial has had a positive effect on these participants, however due to the small sample size no significant difference is observed.

The content of this particular question was highlighted in text. Participants were never (until the test) given access to an image of the fusing iliac crest. Therefore this would be added to aid the understanding of the content of the question.

Question 15 - True / False

"The most superior portion of the pelvis is the iliac crest."

Possible answers: **true**, false or don't know.

Table 33 indicates the results from question 15, test 1 at each level for status 1 and status 2. It can be seen in Table 33 the number of "don't knows" has decreased between status 1 and 2 for all participants. The number of correct answers has also increased for all participants (except 5a). For levels 3 - 5b the number of wrong answers has decreased, however level 1 and 2 show an increase in this area. Results for 5a remain constant.

Level	**Status 1**			**Status 2**		
	Correct	**Wrong**	**Don't know**	**Correct**	**Wrong**	**Don't know**
1	1	1	27	22	5	2
2	3	1	9	10	2	1
3	4	0	19	21	0	2
4	17	1	1	19	0	0
5a	3	1	0	3	1	0
5b	13	1	0	14	0	0
Total	**41**	**5**	**56**	**89**	**8**	**5**

Table 33: Results for question 15 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 34).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	19.17	0.001	2.67	ns	21.55	0.001
2	3.77	ns	0.33	ns	6.4	0.05
3	11.56	0.001	0	ns	13.76	0.001
4	0.11	ns	1	ns	1	ns
5a	0	ns	0	ns	0	ns
5b	0.04	ns	1	ns	0	ns
Total	**17.72**	**0.001**	**0.69**	**ns**	**46.64**	**0.001**

Table 34: Chi-squared results for difference between status 1 and status 2.

Overall a significant difference has been observed for the number of correct answers and the number of "don't knows" answered for all participants. This suggests that the participants learned the content of the question during the completion of the online module.

Level 1 follows the same pattern as all participants together suggesting these participants learned the content from the online tutorials.

Although level 2 shows an increase in correct answers between status 1 and 2 in Table 34 no significant differences were observed. However, a significant difference was observed between the number of "don't knows" answered in status 1 compared to status 2, this may suggest participants are improving, but due to no other significant differences and the small sample size of level 2, no conclusions can be drawn.

Level 3 show significant differences between status 1 and 2 correct answers and "don't knows" suggesting an improvement after completing the online tutorial. Referring back to previous questions, these participants have completed a course in the introduction to

anatomy where they may have learned the content of this particular question.

As discussed earlier levels 4 and 5b were expected to show no significant differences between status 1 and 2 due to their previous knowledge of anatomy which left limited room for improvement in status 2. In addition to level 4 and 5b showing no significant differences, level 5a also demonstrated this.

The term "superior" was required to be understood in order to answer this question correctly. Within the tutorial, in addition to giving the definition of "superior", there was also a short piece of text which stated "the iliac crest is the most superior portion of the innominate." Due to the positive results discussed above, it can be determined that the content assessed in this question was understood following completion of the online module.

Question 16 - Multiple choice

"Which bone(s) contribute to the acetabulum?"

Possible answers: **ilium, ischium, pubis**, femur, sacrum or don't know.

Participants gained one mark for each correct answer, however, for analysis, participants not obtaining full marks have been marked as "wrong." This method may highlight areas where participants did not understanding the content fully.

Table 35 indicates the results from question 16, test 1 at each level for status 1 and status 2. An increase in correct and wrong answers for participants together is observed (Table 35). A decrease in don't knows answered is also observed for all participants between status 1 and 2.

Level 1 and 2 show similar results to all participants together. Level 3, 4, 5a and 5b show an improvement between status 1 and 2.

Level	Status 1			Status 2		
	Correct (3/3)	Wrong (0,1,2/3)	Don't know	Correct (3/3)	Wrong (0,1,2/3)	Don't know
1	0	1	28	9	8	12
2	0	1	12	7	1	5
3	0	2	21	20	2	1
4	14	0	5	19	0	0
5a	1	2	1	4	0	0
5b	11	3	0	14	0	0
Total	**26**	**9**	**67**	**73**	**11**	**18**

Table 35: Results for question 16 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 36).

	Correct		Wrong		Don't know	
Level	Chi-square	p	Chi-square	p	Chi-square	p
1	9	0.01	5.44	0.05	6.4	0.05
2	7	0.01	0	ns	2.88	ns
3	20	0.001	0	ns	18.18	0.001
4	0.76	ns	0	ns	5	0.05
5a	1.8	ns	2	ns	1	ns
5b	0.36	ns	3	ns	0	ns
Total	**22.31**	**0.001**	**0.2**	**ns**	**28.25**	**0.001**

Table 36: Chi-squared results for difference between status 1 and status 2.

A significant difference has been observed for all participants in the number of correct answers answered between status 1 and 2 in addition to a significance decrease in "don't knows" answered between status 1 and 2. These results suggest the participants have learned the content questioned in question 16.

Level 1 showed a significant difference between the number of correct answers answered between status 1 and 2. They also showed a significant difference in the number of "don't knows" answered. These results suggest tutorial 1 gave these participants the knowledge to answer the question. However, an increase in wrong answers is also observed in Table 31 which was found to be significant. This suggests that although some participants in this level are improving, others are not. Figure 13 shows the actual answers participants in level 1 gave. It can be seen that although a high number of wrong answers have been observed in (Table 35), there are no actual wrong answers in status 2, the participants discussed in Table 31 were marked wrong as they did not receive full marks. However, although a number of participants are receiving between 1 and 2 marks out of 3, they did not understand the subject fully.

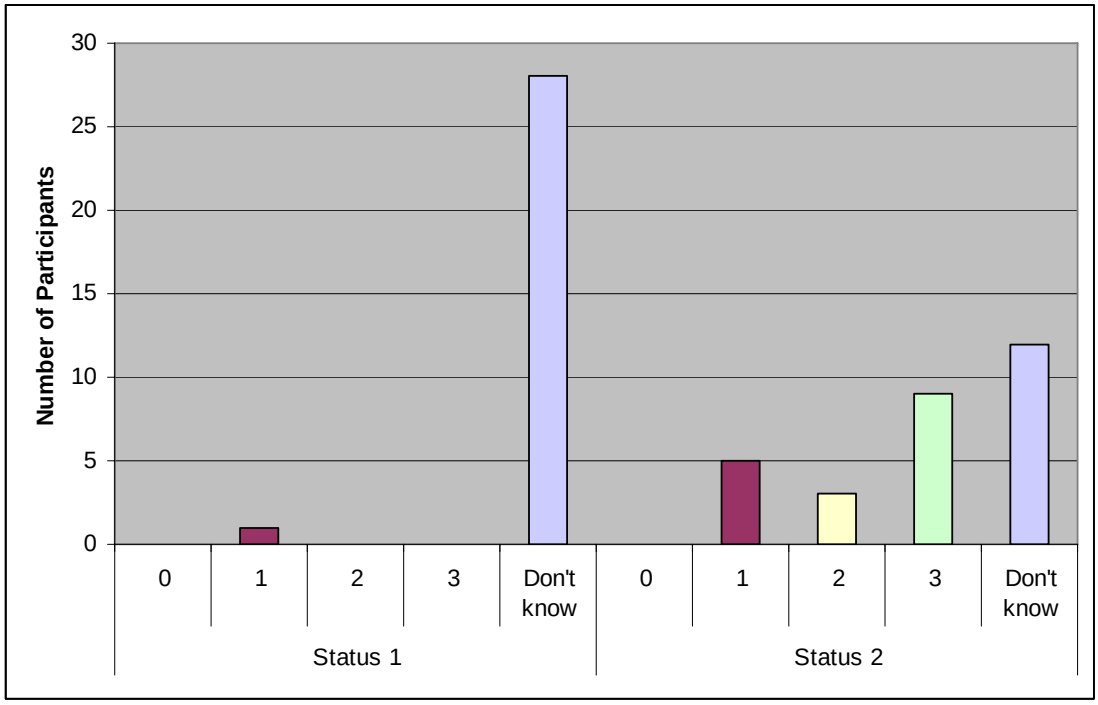

Figure 34: Actual answers for question 16 for level 1.

A significant difference between the number of correct answers between status 1 and 2 for level 2 have been observed. This suggests these participants learned the content assessed in the question following tutorial 1.

Level 3 show significant differences between status 1 and 2 correct answers and "don't knows" suggesting an improvement after completing the online tutorial. Referring back to previous questions, these participants have completed a course in the introduction to anatomy where they may have learned the content of this particular question.

A significant decrease in the number of "don't knows" answered between status 1 and 2 has been demonstrated by level 4. It was expected that these participants would score high in status 1, however in this case their scores appear to be improved following the online tutorials. However, between status 1 and 2, level 4 participants completed modules in gross anatomy and human

osteology, which may have led to the 5 participants stating don't know in status 1 learning the content by status 2.

As discussed earlier levels 4 and 5b were expected to show no significant differences between status 1 and 2 due to their previous knowledge of anatomy which left limited room for improvement in status 2. In addition to level 4 and 5b showing no significant differences, level 5a also demonstrated this.

The content of this question was discussed through text and images within the tutorial. As the majority of participants improved between status 1 and 2, it could be suggested that this area was addressed appropriately. However, as status 2 correct answers were not 100%, there is room for improvement. More labelling activities may aid participants learning this particular region.

The acetabulum is discussed in more detail in tutorial 2, therefore, this question will be reassessed in tutorial 2 analysis and compared to the results shown here.

Question 17 - Multiple choice

"The inguinal ligament attaches to which bony elements?"

Possible answers: **anterior superior iliac spine,** anterior inferior iliac spine, ischial tuberosity, ischial spine, pubic symphysis**, pubic tubercle** or don't know.

Participants gained one mark for each correct answer, however, for analysis, participants not obtaining full marks have been marked as wrong. This method may highlight areas where participants did not understand the content fully.

Table 37 indicates the results from question 17, test 1 at each level for status 1 and status 2. An increase in correct and wrong answers between status 1 and 2 for all participants together is observed in Table 33. A decrease in "don't knows" answered is also observed for all participants between status 1 and 2.

Level 1-4 show similar results as all participants together. Level 5a and 5b show an improvement between status 1 and 2 as the number of wrong answers decreases between status 1 and 2.

Level	**Status 1**			**Status 2**		
	Correct (2/2)	**Wrong (0,1/2)**	**Don't know**	**Correct (2/2)**	**Wrong (0,1/2)**	**Don't know**
1	0	1	28	9	9	19
2	0	2	11	1	3	9
3	0	1	22	19	4	0
4	15	2	2	13	6	0
5a	0	1	3	1	2	1
5b	8	5	1	11	2	1
Total	**23**	**12**	**67**	**54**	**26**	**30**

Table 37: Results for question 17 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 38).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	9	0.01	6.4	0.05	1.72	ns
2	1	ns	0.2	ns	0.2	ns
3	19	0.001	1.8	ns	22	0.001
4	0.14	ns	2	ns	2	ns
5a	1	ns	0.67	ns	1	ns
5b	0.47	ns	0.64	ns	0	ns
Total	**12.48**	**0.001**	**5.16**	**0.05**	**14.11**	**0.001**

Table 38: Chi-squared results for difference between status 1 and status 2.

Overall participant scores show a significant decrease in the number of "don't knows" answered. However, an increase in correct answers has been observed as has an increase in wrong answers. As the significance level of wrong answers is less than that of the correct answers it can be determined that overall tutorial 1 had a positive effect on participants answering this question. However as there is an increase in wrong answers, the content of the question was not fully understood by all participants.

Level 1 shows a significant increase in the number of correct answers between status 1 and 2. This suggests a positive effect; however there was also a significant increase in wrong answers, which suggests a negative effect. As a high number of "don't knows" remains in status 2, it can be suggested that this area was not fully understood by the majority of this level.

Level 2 shows similar results to level 1, with a small increase in the number of correct and wrong answers, and the high number of don't knows answered in status 1 drops slightly in status 2. The results between status 1 and 2 show no significant differences as there is little changes between status 1 and 2. This suggests the majority of

participants in this level did not learn the content assessed in question 17.

Level 3 show significant differences between status 1 and 2 correct answers and "don't knows" suggesting an improvement after completing the online tutorial. Referring back to previous questions, these participants have completed a course in the introduction to anatomy where they may have learned the content of this particular question.

As discussed earlier levels 4 and 5b were expected to show no significant differences between status 1 and 2 due to their previous knowledge of anatomy which left limited room for improvement in status 2. In addition to level 4 and 5b showing no significant differences, level 5a also demonstrated this.

The content of this question was addressed through a 2D image, showing the adult pelvis with the attachments of the inguinal ligament highlighted. Although the results above were overall positive, there is room to improve this particular area as there was still a high number of participants who did not know the answer following completion of the tutorial.

Question 18; Drag and drop

"Assign a sex to each of the following pelves by dragging the label over the appropriate pelvis"

There was one male and one female pelvis for participants to sex.
Participants gained one mark for each correct answer, however, for analysis, participants not obtaining full marks have been marked as wrong. This method may highlight areas which participants did not understand the content fully.

Table 39 indicates the results from question 18, test 1 at each level for status 1 and status 2. A high number of correct answers can be observed in status 1 for all participants together in addition to the individual levels.

The number of correct answers has increased for levels 1, 2, 3 and 5a and 5b, suggesting a positive effect. The number of wrong answers has dropped for levels 1, 2, 3 and 5a and remains the same between status 1 and 2 for level 4. The total number of don't knows has decreased, however theses were low initially.

Level	**Status 1**			**Status 2**		
	Correct (2/2)	**Wrong (0,1/2)**	**Don't know**	**Correct (2/2)**	**Wrong (0,1/2)**	**Don't know**
1	19	4	6	26	3	0
2	11	2	0	13	0	0
3	15	5	3	22	1	0
4	16	3	0	16	3	0
5a	3	1	0	4	0	0
5b	14	0	0	13	1	0
Total	**78**	**15**	**9**	**94**	**8**	**0**

Table 39: Results for question 18 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 40).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	1.09	ns	0.14	ns	6	0.05
2	1.67	ns	2	ns	0	ns
3	1.32	ns	2.67	ns	3	ns
4	0	ns	0	ns	0	ns
5a	0.14	ns	1	ns	0	ns
5b	0.04	ns	1	ns	0	ns
Total	**1.49**	**ns**	**1.07**	**ns**	**9**	**0.01**

Table 40: Chi-squared results for difference between status 1 and status 2.

A significant decrease between the number of "don't knows" answered in status 1 compared to status 2 has been observed for all participants. A significant decrease has also been observed in the number of don't knows answered by level 1 in status 1 and 2.

Although these differences have been observed, no others reduced statistical significance. Due to the high number of correct answers in status 1, there was little room for participants to improve. These results suggest the participants knew the content of question 18 before completing the online tutorial. Question 18 asked participants to assign a sex to two pelves using the labels (male and female). Neither had ambiguous features, one had extreme male features and the other female. Therefore this question was not necessarily difficult and participants without prior knowledge in this area could make an educated guess accurately.

Question 19; Drag and drop

"Drag these labels to the appropriate bony element"

This drag and drop question used an image of the right innominate. Participants were asked to label the ilium, ischium and pubis.

Participants gained one mark for each correct answer, however, for analysis, participants not obtaining full marks have been marked as "wrong." This method may highlight areas which participants did not understand the content fully.

Table 41 indicates the results from question 19, test 1 at each level for status 1 and status 2. An overall increase in correct answers and a decrease in wrong and "don't knows" answered for all participants is observed in Table 41.

Level 1 however, show an increase in the number of correct answers and wrong answers between status 1 and 2 which shows some participants improved whilst others did not. Levels 2, 3, 4, 5a and 5b all show an increase in correct answers and a decrease in wrong answers suggesting tutorial 1 improved their knowledge of the content of this particular question.

Level	**Status 1**			**Status 2**		
	Correct (3/3)	**Wrong (0,1,2/3)**	**Don't know**	**Correct (3/3)**	**Wrong (0,1,2/3)**	**Don't know**
1	11	1	17	16	9	4
2	2	5	6	10	2	1
3	3	6	14	23	0	0
4	15	4	0	19	0	0
5a	1	3	0	4	0	0
5b	13	1	0	14	0	0
Total	**45**	**20**	**37**	**86**	**11**	**5**

Table 41: Results for question 19 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 42).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	0.93	ns	6.4	0.05	8.05	0.01
2	5.33	0.05	1.29	ns	3.57	ns
3	15.38	0.001	6	0.05	14	0.001
4	0.47	ns	4	0.05	0	ns
5a	1.8	ns	3	ns	0	ns
5b	0.04	ns	1	ns	0	ns
Total	**12.83**	**0.001**	**2.61**	**ns**	**24.38**	**0.001**

Table 42: Chi-squared results for difference between status 1 and status 2.

A significant increase in the number of correct answers and "don't knows" answered between status 1 and 2 have been observed for all participants. These results suggest tutorial 1 had a positive effect on status.

Level 1 however does not follow the same pattern and a significant difference has been observed in the number of wrong answers. Referring back to Table 41 an increase in wrong answers can be observed, suggesting the content was not learned by a significant number of participants in this group but perhaps confidence increased.

Level 2 show a significant difference in correct answers between status 1 and 2, suggesting they had learned the content of the question in tutorial 1.

Level 3 show significant differences between status 1 and 2 correct answers and "don't knows" suggesting an improvement after completing the online tutorial. Referring back to previous questions, these participants have completed a course in the introduction to anatomy where they may have learned the content of this particular question.

As discussed earlier levels 4 and 5b were expected to show no significant differences between status 1 and 2 due to high scores in status 1 (Table 42). Level 4 however showed a significant decrease in wrong answers between status 1 and 2. However, between status 1 and 2, level 4 participants completed modules in gross anatomy and human osteology, which may have led to this significant improvement.

The content of this question was discussed in great length in tutorial 1. Although a high number of correct answers was observed in status 2, it is important for participants to learn this concept in adult form before continuing onto the development in tutorial 2. As this term is addressed again in tutorial 2, therefore this question will be reassessed in test 2 analysis.

Question 20; Drag and drop

"Label the following structures"

This drag and drop question used an image of an adult pelvis. Participants were asked to label the pubic symphysis, anterior superior iliac spine, iliac crest and iliac fossa.

Participants gained one mark for each correct answer, however, for analysis, participants not obtaining full marks have been marked as "wrong." This method may highlight areas where participants did not understanding the content fully.

Table 43 indicates the results from question 20, test 1 at each level for status 1 and status 2. An overall increase in correct answers and a decrease in wrong and "don't knows" answered by all participants is observed in Table 43.

Level 1 however, show an increase in the number of correct answers and wrong answers between status 1 and 2 which shows some participants improved whilst others did not. Levels 2, 3, 4, 5a and 5b all show an increase in correct answers and a decrease in wrong answers suggesting tutorial 1 improved their knowledge of the content of this particular question.

Level	**Status 1**			**Status 2**		
	Correct (4/4)	**Wrong (0,1,2,3/4)**	**Don't know**	**Correct (4/4)**	**Wrong (0,1,23/4)**	**Don't know**
1	2	8	19	9	15	5
2	2	8	3	9	2	2
3	2	7	14	20	3	0
4	13	5	1	19	0	0
5a	1	3	0	2	2	0
5b	14	0	0	13	1	0
Total	**34**	**31**	**37**	**72**	**23**	**7**

Table 43: Results for question 20 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 44).

	Correct		**Wrong**		**Don't know**	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	4.45	0.05	2.13	ns	8.17	0.01
2	4.45	0.05	3.6	ns	0.2	ns
3	14.73	0.001	1.6	ns	14	0.001
4	1.13	ns	5	0.05	1	ns
5a	0.33	ns	0.2	ns	0	ns
5b	0.04	ns	1	ns	0	ns
Total	**13.62**	**0.001**	**1.18**	**ns**	**20.45**	**0.001**

Table 44: Chi-squared results for difference between status 1 and status 2.

A significant increase in the number of correct answers and "don't knows" answered between status 1 and 2 have been observed for all participants. These results suggest tutorial 1 has had a positive effect on status.

Although level 1 did not follow the same pattern as all participants together (Table 43) the results of the chi-squared calculations show a significant difference in the number of correct answers between status 1 and 2. However, referring back to Table 39 an increase in wrong answers can be observed. This result was found not to be significant and results for level 1 show they have improved between status 1 and 2.

Level 2 showed a significant difference in correct answers between status 1 and 2, suggesting they had learned the content of the question in tutorial 1.

Level 3 showed significant differences between status 1 and 2 correct answers and don't knows suggesting an improvement after completing the online tutorial. Referring back to previous questions, these participants have completed a course in the introduction to anatomy where they may have learned the content of this particular question.

As discussed earlier levels 4 and 5b were expected to show no significant differences between status 1 and 2 due to high scores in status 1 (Table 43). Level 4 however showed a significant decrease in wrong answers between status 1 and 2. However, between status 1 and 2, level 4 participants completed modules in gross anatomy and human osteology, which may have led to this significant improvement.

The content of this question was discussed through text and images within the tutorial. As the majority of participants improved between status 1 and 2, it could be suggested that this area was addressed appropriately. However, as status 2 correct answers were not 100%, there is room for improvement. More labelling activities may aid participants learning this particular region.

Conclusion of test 1 analysis

Although test scores between status 1 and 2 have improved for each level (Figure 25), the chi-squared analyses on individual questions has highlighted a number of weaknesses which would require readdressing should the online tutorial continue.

Level 1 show a large increase in score between status 1 and 2, however, the average score by status 2 was under 50% which is below the pass rate for their current degree program. As these participants had limited (if any) knowledge of basic anatomy in addition learning the morphology of the adult innominate they also required some knowledge of anatomical terminology, therefore understanding may have been hindered.

As the total number of "don't knows" answered in test 2 by level 1 has decreased significantly, it can be said that although these participants were not obtaining the correct answer, they were more confident to answer the questions by status 2, as seen by the decrease in "don't knows" from each question.

Level 2 show a similar decrease in "don't knows" answered between status 1 and 2, which also suggests improved confidence. Their score also showed that tutorial 2 had improved their knowledge on the development of the skeleton, however the average pass mark in

status 2 was just over 50% which is below the grade required to remain in their current degree. However, this level also had limited knowledge of anatomical terminology which may have hindered their understanding.

The results for level 3 and 4 cannot be used to determine the suitability of tutorial 1 as these participants completed face-to-face modules in relevant subject. Therefore their results cannot solely be based on them learning the material from the online tutorial.

Level 5 consist of staff and postgraduate students with mixed backgrounds in human anatomy. This group were subsequently divided into participants without prior knowledge of anatomy (5a) and participants with previous knowledge (5b). As expected participants in 5b did not show improvements as they had previous knowledge, level 5a on the other hand showed improvements following completion of tutorial 1.

Overall, participants have improved their knowledge of the adult innominate between status 1 and 2. The knowledge gained from this particular tutorial should aid them in the understanding and completion of tutorial 2.

4.1.2: Test 2 Analysis

As participants were from mixed levels, statistical analysis on scores from status one and two was undertaken between levels to observe whether the status had an effect on the score of test 2.

Status two shows an increase from status one for all levels suggesting tutorial 2 had a positive effect on all the participants (figure 35). The error bars suggest there is a significant difference between status one and two for levels 1 - 3 and 5. However, level 4

shows a smaller increase in percentage score obtained in status two compared to status one suggesting status may not have as positive an effect on score in this case. Statistical analyses were carried out to observe any significance in these findings.

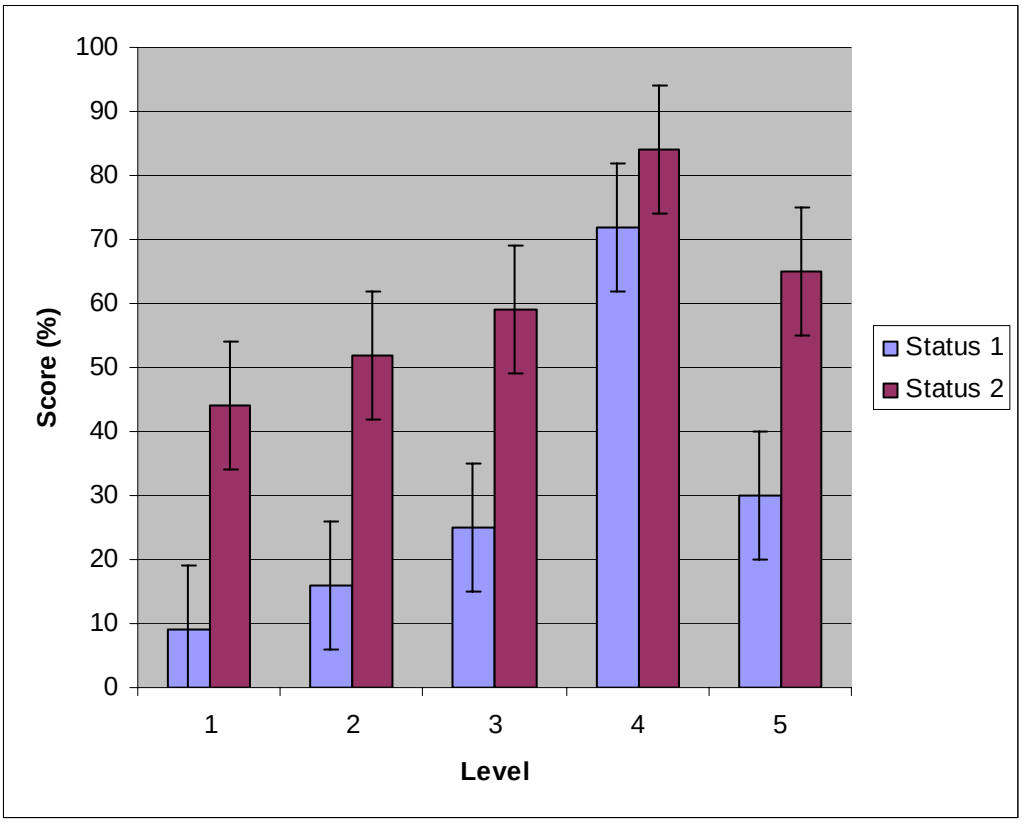

Fig 35: Test 2 scores for each level for status 1 and status 2

A two way analysis of variance was carried out to test if there is an interaction between level and status. The ANOVA demonstrated a significant difference between status and score ($F=208.447$; $p<0.001$), it also shows there is a significant difference between level and score ($F=85.245$; $p<0.001$). A significant interaction between level and status has also been identified ($F=5.397$; $p<0.001$) which will be considered further.

In order to analyse the significance of the increase in score for each level independently, one-way analyses of variance were carried out for each level.

There were high significant differences between scores obtained in status 1 and status 2 identified for tutorial 2;

Level 1 - (H=37.041; p<.001)

Level 2 - (F=49.260; p<.001)

Level 3 - (F=94.157; p<.001)

Level 4 - (H=9.037; p<.05)

Level 5 - (F=15.228; p<.001)

Level 5 had little experience with the development of the skeleton; therefore there was no need to split this group for analysis.

All the results above have supported the initial proposition that the tutorials would have a positive effect on score. Statistical analyses were undertaken for individual questions for further investigation. Levels 1-3 and 5 showed the largest improvement which is expected as level 4 had previous training in the subject. However, the performance of level 4 did improve.

The analyses of variance carried out above calculated the overall response for tutorial 2 (status 1 vs. status 2) for each level. Test 2 was then divided into the individual questions of the test in order to address specific areas within the tutorials.

In order to avoid participants guessing answers to questions, they were given the option to choose don't know and strongly directed to choose this option when appropriate. If the online tutorials had a positive effect on results, the number of "don't knows" would decrease. However this was not always the case, as seen in some questions discussed below. In these cases, not all levels improved, which may indicate areas of the tutorials which may require to be addressed to improve their appropriateness.

Question 1 - Fill in the blank

*"Bone is laid down in a progressive process known as **ossification."***

Table 45 indicates the results from question 1, test 2 at each level for status 1 (before completing tutorial 2) and status 2 (after completing tutorial 2). It can be seen that overall the number of "don't knows" has decreased between status 1 and 2, as have the number of wrong answers. The total number of correct answers has increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on participants score.

All Levels show individual improvement as the number of "don't knows" answered has decreased whilst the number of correct answers has increased.

Level	**Status 1**			**Status 2**		
	Correct	**Wrong**	**Don't know**	**Correct**	**Wrong**	**Don't know**
1	4	1	21	21	1	4
2	1	1	12	12	2	0
3	14	10	2	25	1	0
4	14	3	2	18	1	0
5	13	3	4	16	3	1
Total	**46**	**18**	**41**	**92**	**8**	**5**

Table 45: Results for question 20 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 46).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	11.56	0.001	0	ns	11.56	0.001
2	9.31	0.01	0.33	ns	12	0.001
3	3.1	ns	7.36	0.01	2	ns
4	0.5	ns	1	ns	2	ns
5	0.31	ns	0	ns	1.8	ns
All Participants	**15.33**	**0.001**	**3.85**	**ns**	**28.17**	**0.001**

Table 46: Chi-squared results for difference between status 1 and status 2.

Table 46 shows a significant difference in the increase of correct answers and the decrease in "don't knows" answered between status 1 and 2. These results demonstrate that tutorial 2 has had a positive effect on all participants.

Results from Level 1 and 2 also suggest that tutorial 2 has had a positive effect as the number of correct answers has increased significantly and the number of "don't knows" answered has decreased significantly.

Level 3 show no significant differences between the number of correct answers or "don't knows" answered between status 1 and 2, suggesting that tutorial 2 did not teach participants the content required to answer question 1. However, the number of wrong answers have decreased significantly suggesting participants initially answering wrongly have learned the content of the question during tutorial 2.

The number of correct answers for level 4 and 5 were high in status 1 which shows the majority of participants knew this information prior

to completing status 1. The room for improvement is therefore limited and although an increase in correct answers can be seen for both levels, results found no significant differences in the results. These results were expected by level 4 participants as they completed a module in Human Osteology prior to status 1. Although level 5 has a mixed background in osteology (staff, post-grads) their knowledge on this particular area was there prior to status 1.

This particular question was successfully understood by the majority of participants following completion of tutorial 2. The term ossification was used throughout tutorial 2, giving participants the knowledge they required to answer the question. Although fill in the blank questions have previously caused problems with spelling mistake, this particular question was not affected. However, a number of alternative answers were used which were just as accurate (such as osteogenesis and deposition) but were marked wrong. In the future a number of correct answers will be accepted.

Question 2 - True / false

"All three primary centres of ossification of the innominate are present at birth"

Possible answers: **true**, false or don't know.

Table 47 indicates the results from question 2, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2, as have the number of wrong answers. The total number of correct answers has increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on participants.

Levels 1-3 and 5 show individual improvements as the number of "don't knows" answered has decreased whilst the number of correct

answers has increased. Level 4 shows no change as expected as the number of correct answers is high in status 1.

Level	Status 1			Status 2		
	Correct ("true")	Wrong ("false")	Don't know	Correct ("true")	Wrong ("false")	Don't know
1	3	6	17	17	6	3
2	5	3	6	12	1	1
3	9	8	9	18	6	2
4	18	1	0	18	1	0
5	8	1	11	17	3	0
Total	**43**	**19**	**43**	**82**	**17**	**6**

Table 47: Results for question 2 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 48).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	9.8	0.01	0	ns	9.8	0.01
2	2.88	ns	1	ns	3.57	ns
3	3	ns	0.29	ns	4.45	0.05
4	0	ns	0	ns	0	ns
5	3.24	ns	1	ns	11	0.001
All Participants	**12.17**	**0.001**	**0.11**	**ns**	**27.94**	**0.001**

Table 48: Chi-squared results for difference between status 1 and status 2.

Table 48 shows a significant difference in the total number of correct and "don't knows" answered between status 1 and 2. These results demonstrate that tutorial 2 has had a positive effect on participants.

Results from Level 1 suggest that tutorial 2 has had a positive effect as the number of correct answers has increased significantly and the number of "don't knows" answered has decreased significantly.

Level 2 showed no significant difference between any answers in status 1 compared to status 2. Although an increase in correct answers and a decrease in wrong and “don’t knows” answered between status 1 and 2 is observed (Table 47), no significant differences have been calculated. This may be due to the small sample size of level 2.

Level 3 showed no significant difference between the number of correct, wrong or "don't knows" answered between status 1 and 2, suggesting that tutorial 2 had no effect on answering this question.

The number of correct answers for level 4 was high in status 1 which shows participants knew this information prior to completing status 1. The room for improvement was therefore limited and although an increase in correct answers can be seen for both levels, results found no significant differences in the results. These results were expected by both level 4 as these participants completed a module in Human Osteology prior to status 1.

The number of “don’t knows” answered by level 5 have significantly decreased by status 2. An increase in correct and wrong answers is apparent however, no significant differences between status 1 and 2 were found, and therefore full understanding has not been demonstrated.

This particular question is addressed throughout tutorial 2. Although increases in correct answers can be seen for all levels (except level 4), not all differences were found to be significant. This area may

require further explanation to ensure participants fully understand the content. Question 2 could be described as a more challenging question (compared to others) as it requires participants to learn the timing of the appearance of ossification centres which is complex and involves learning a sequential pattern.

Question 3 - True / False

"The innominate develops from both primary and secondary centres of ossification."

Possible answers: **true**, false or don't know.

Table 49 indicates the results from question 3, test 2 at each level for status 1 and status 2. It can be seen that overall the total number of "don't knows" has decreased between status 1 and 2, and the number of wrong answers remain the same. The total number of correct answers has increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on participants.

Levels 1-3 and 5 each show improvement as the number of "don't knows" answered has decreased whilst the number of correct answers has increased. However, level 1 and 5 also show an increase in wrong answers between status 1 and 2 which suggest weaknesses. Level 4 shows no change as expected as there is 100% accuracy in status 1 and 2.

Level	Status 1			Status 2		
	Correct ("true")	Wrong ("false")	Don't know	Correct ("true")	Wrong ("false")	Don't know
1	2	1	23	21	4	1
2	3	2	9	12	1	1
3	12	4	10	25	1	0
4	19	0	0	19	0	0
5	11	0	9	19	1	0
Total	**47**	**7**	**51**	**96**	**7**	**2**

Table 49: Results for question 3 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 50).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	15.7	0.001	1.8	ns	20.17	0.001
2	5.4	0.05	0.33	ns	6.4	0.05
3	4.57	0.05	1.8	ns	10	0.001
4	0	ns	0	ns	0	ns
5	2.13	ns	1	ns	9	0.01
All Participants	**16.79**	**0.001**	**0**	**ns**	**45.3**	**0.001**

Table 50: Chi-squared results for difference between status 1 and status 2.

Table 50 shows a significant difference in the total number of correct and "don't knows" answered between status 1 and 2. These results demonstrate that tutorial 2 has had a positive effect on participants. Results from Level 1-3 suggest that tutorial 2 has had a positive effect as the number of correct answers has increased significantly and the number of "don't knows" answered has decreased significantly. Although level 1 shows a small increase in wrong answers (Table 49) this was not found to be significant.

As expected, level 4 knew the content before status 1, therefore no changes in answers were observed.

The number of "don't knows" answered by level 5 have significantly decreased by status 2. Although an increase in correct and wrong answers is observed between status 1 and 2 (Table 49), results were found not to be significant.

Tutorial 2 focuses on both the primary and secondary development of the innominate bone. It would be expected that the majority of participants would learn this information as it was mentioned throughout the tutorial, however if participants did not understand the concept initially they may not gain the knowledge. As the majority of participants improved it can be suggested that this question was successful and the external link used aided participants in answering the question. However, in the future should the project continue into other regions of the skeleton, an introductory tutorial into ossification will be created to ensure participants understand the concept before continuing with specific areas of the skeleton.

Question 4 - True / False

"A primary ossification centre may form the entirety of a bone."

Possible answers: **true**, false or don't know.

Table 51 indicates the results from question 4, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct answers have increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on participants. However, a small increase in wrong answers is also observed.

Level 1 and 3 also show these results. Level 2 and 5 show improvements as the correct answers have increased between status 1 and 2 and the number of "don't knows" has decreased. Although there is a high number of correct answers for level 4 status 1 and 2 a decrease in correct answers and an increase in wrong answers is shown which suggests tutorial 2 has had a negative effect on level 4.

Level	**Status 1**			**Status 2**		
	Correct ("true")	**Wrong ("false")**	**Don't know**	**Correct ("true")**	**Wrong ("false")**	**Don't know**
1	3	2	21	19	5	2
2	4	2	8	11	2	1
3	19	3	4	18	4	4
4	17	2	0	15	4	0
5	9	3	8	15	3	2
Total	**52**	**12**	**41**	**78**	**18**	**9**

Table 51: Results for question 4 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 52).

	Correct		**Wrong**		**Don't know**	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	11.64	0.001	1.29	ns	15.70	0.001
2	3.27	ns	0	ns	5.44	0.05
3	0.03	ns	0.14	ns	0	ns
4	0.13	ns	0.67	ns	0	ns
5	1.5	ns	0	ns	3.6	ns
All Participants	**5.2**	**0.05**	**1.2**	**ns**	**20.48**	**0.001**

Table 52: Chi-squared results for difference between status 1 and status 2.

Table 52 shows a significant difference in the total number of correct and "don't knows" answered between status 1 and 2. These results

demonstrate that tutorial 2 has had a positive effect on participants. Although a small increase in wrong answers is observed in Table 51, this was found not to be significant which further supports the positive effect of tutorial 2.

Results from Level 1 suggest that tutorial 2 has had a positive effect as the number of correct answers has increased significantly and the number of "don't knows" answered has decreased significantly. Although level 1 showed an increase in wrong answers (Table 51) this was not found to be significant.

Level 2 shows a significant decrease in the number of "don't knows" answered between status 1 and 2, however no other significant differences were observed. Although an increase in the number of correct answers is observed in Table 51, no significant differences were calculated in Table 52 therefore a positive effect can not be determined. These may be due to sample size.

No significant differences have been observed for levels 3-5. This may be due to the high results observed in status 1.

Other than a brief introduction and an external link on the description of ossification, participants were not given any information on bones which developed from primary centres only (as the innominate develops from primary and secondary centres). As a significant increase in correct answers has been observed, it could be concluded that the introduction and external link was understood by the majority of participants. In the future should the project continue into other regions of the skeleton, an introductory tutorial into ossification will be created and tested on participants to ensure they understand the concept before continuing with specific areas of the skeleton.

Question 5 - Multiple choice

"Fusion of the innominate is first seen between 5 and 8 years in the region of the...."

Possible answers: acetabulum, iliac crest, **ischiopubic ramus**, superior ramus or don't know.

Table 53 indicates the results from question 5, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct answers have increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on participants. However, a small increase in wrong answers is also observed.

Between status 1 and 2 level 1 shows a larger increase in wrong answers than correct answers, which suggests tutorial 2 has had a negative effect. Levels 2, 4 and 5 results on the other hand indicate tutorial 2 has had a positive effect. An increase in correct and wrong answers is observed in level 3, which suggests participants did not fully understand the content.

Level	**Status 1**			**Status 2**		
	Correct	**Wrong**	**Don't know**	**Correct**	**Wrong**	**Don't know**
1	0	3	23	6	12	8
2	0	5	9	8	3	3
3	3	4	19	12	9	5
4	11	5	3	17	1	1
5	8	5	7	12	5	3
Total	**22**	**22**	**61**	**55**	**30**	**20**

Table 53: Results for question 5 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 54).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	6	0.05	5.4	0.05	7.26	0.01
2	8	0.01	0.05	ns	3	ns
3	5.4	0.05	1.92	ns	8.17	0.01
4	1.29	ns	2.67	ns	1	ns
5	0.8	ns	0	ns	1.6	ns
All Participants	**14.14**	**0.001**	**1.23**	**ns**	**20.75**	**0.001**

Table 54: Chi-squared results for difference between status 1 and status 2.

Table 54 shows a significant difference in the total number of correct and "don't knows" answered between status 1 and 2. These results demonstrate that tutorial 2 has had a positive overall effect on participants. Although a small increase in wrong answers in observed in Table 53, this was found not to be significant which further supports the positive effect of tutorial 2.

Significant increases were found for correct and wrong answers between status 1 and 2 for level 1. This suggests participants have gained false confidence.

A significant increase in correct answers has been demonstrated by level 2 and 3. This further supports that tutorial 2 has had a positive effect on participants.

No significant differences have been observed for levels 4 and 5. This may be due to the high results observed in status 1. The room for

improvement was therefore limited and although an increase in correct answers can be seen for levels 5, results showed no significant differences.

The content of this question was addressed in tutorial 2 through image and text description. Although there was a significant improvement for all participants together, not all levels displayed the same results. Although the number of "don't knows" answered has decreased in all levels, positive results have not always been observed. Therefore it can be concluded that perhaps participants are gaining the confidence following completion of tutorial 2, however they are not gaining the knowledge required to support it.

In the future it could be suggested that sound recordings would be included to give participants the option to read or listen. Having these options will give participants more freedom, but may also increase understanding through addressing different learning styles.

Question 6 - True / False

"The primary centres of ossification of the innominate are highlighted in green"

Possible answers: true, **false** or don't know.

Table 55 indicates the results from question 6, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct answers have increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on participants. However, a small increase in wrong answers is also observed.

Between status 1 and 2 Level 1 shows the same increase in wrong answers and correct answers, drawing no conclusions about participants understanding of the content. Results from Level 2, 3 and 5 indicate that tutorial 2 has had a positive effect. Level 4 shows no change as expected as there is 100% accuracy in status 1 and 2.

Level	**Status 1**			**Status 2**		
	Correct ("true")	**Wrong ("false")**	**Don't know**	**Correct ("true")**	**Wrong ("false")**	**Don't know**
1	2	2	22	12	12	2
2	2	3	9	8	3	3
3	1	8	17	22	2	2
4	19	0	0	19	0	0
5	13	1	6	19	1	0
Total	**37**	**14**	**54**	**80**	**18**	**7**

Table 55: Results for question 6 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 56).

	Correct		**Wrong**		**Don't know**	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	7.14	0.01	7.14	0.01	16.67	0.001
2	3.6	ns	0	ns	3	ns
3	19.17	0.001	3.6	ns	11.84	0.001
4	1.29	ns	2.67	ns	1	ns
5	1.13	ns	0	ns	6	0.05
All Participants	**15.8**	**0.001**	**0.5**	**ns**	**36.21**	**0.001**

Table 56: Chi-squared results for difference between status 1 and status 2.

Table 56 shows a significant difference in the total number of correct and "don't knows" answered between status 1 and 2. These results demonstrate that tutorial 2 has had a positive effect on participants. Although a small increase in wrong answers in observed in Table 55, this was found not to be significant which further supports the positive effect of tutorial 2.

Significant increases were found for correct and wrong answers between status 1 and 2 for level 1. This suggests participants have gained false confidence.

No significant differences have been observed for level 2. Although an increase is observed in the number of correct answers between status 1 and 2, this was not found to be significant. These results may be due to a small sample size.

Level 3 show the only significant positive results as the number of correct answers has increased and the number of "don't knows" answered has decreased between status 1 and 2.

No significant results have been observed for levels 4 and 5. This may be due to the high results observed in status 1. The room for improvement was therefore limited and although an increase in correct answers can be seen for levels 5, results showed no significant differences.

Answering this question correctly required understanding of primary and secondary ossification. This subject was addressed at various points in tutorial 2, however if the content was not understood initially, improvements may not be seen. Overall results for this question improved. However, as there were little improvements observed in individual levels this area would be readdressed in the

future and a tutorial on ossification would be introduced before participants continued with the development of specific regions of the skeleton.

Question 7 - Multiple choice

Side this perinate ilium

Possible answers: right, **left** or don't know

Table 57 indicates the results from question 7, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct answers have increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on participants. However, a small increase in wrong answers is also observed.

Level 1 shows a large increase in correct answers; however it also shows a small increase in wrong answers. Level 2 and 3 show an increase in wrong answers suggesting tutorial 2 has had a negative effect on score. Level 4 and 5 results suggest tutorial 2 has had a positive effect as correct answers have increased.

Level	**Status 1**			**Status 2**		
	Correct	**Wrong**	**Don't know**	**Correct**	**Wrong**	**Don't know**
1	1	3	22	15	5	6
2	3	4	7	3	9	2
3	13	7	6	12	13	1
4	13	6	0	18	1	0
5	8	8	4	11	8	1
Total	**38**	**28**	**39**	**59**	**36**	**10**

Table 57: Results for question 7 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 58).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	12.25	0.001	0.5	ns	9.14	0.01
2	0	ns	1.92	ns	2.78	ns
3	0.04	ns	1.8	ns	3.57	ns
4	0.81	ns	3.57	ns	0	ns
5	0.47	ns	0	ns	1.8	ns
All Participants	**4.55**	**0.05**	**1**	**ns**	**17.16**	**0.001**

Table 58: Chi-squared results for difference between status 1 and status 2.

Table 58 shows a significant difference in the total number of correct and "don't knows" answered between status 1 and 2. These results demonstrate that tutorial 2 has had a positive effect on participants. Although a small increase in wrong answers in observed in Table 57, this was found not to be significant which further supports the positive effect of tutorial 2.

The only level to show significant improvement between status 1 and 2 was level 1 as the number of correct answers increased significantly whilst the number of "don't knows" answered decreased significantly between status 1 and 2.

No significant differences have been observed for level 2. Although an increase is observed in the number of wrong answers between status 1 and 2, this was not found to be significant. These results may be due to the small sample size.

No significant results have been observed for levels 4 and 5. This may be due to the high results observed in status 1. The room for improvement is limited and although an increase in correct answers can be seen for these levels, results found no significant differences.

This was a complex question which requires a sophisticated knowledge base in order to answer it correctly. This question relied not only on participants knowing specific features on the perinatal ilium, but also required them to assign the side in which it originated. Overall results for this question improved. However, as there were little improvements observed in individual levels this area would be readdressed in the future. More siding activities would be available in addition to 3D labelling activities which would make the task more realistic and allow users to visualise the object in 3D.

Question 8 - Multiple choice

"*The red arrow is pointing to the* ***pubic symphysis****. The blue arrow is pointing to the* ***acetabular surface****."*

Possible answers: auricular surface, acetabular surface, pubic symphysis or don't know.

Participants gained one mark for each correct answer, however, for analysis, participants not obtaining full marks have been marked as wrong. This method may highlight areas where participants do not understand fully the content of the question.

Table 59 indicates the results from question 8, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct answers have increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on

participants. However, an increase in wrong answers is also observed.

All levels show an increase in correct answers, however an increase in wrong answers is also observed in levels 1, 3 and 5.

Level	Status 1			Status 2		
	Correct (2/2)	Wrong (0,1/2)	Don't know	Correct (2/2)	Wrong (0,1/2)	Don't know
1	0	3	23	4	12	10
2	0	5	9	1	4	9
3	2	11	13	9	14	3
4	10	8	1	12	6	1
5	6	8	6	7	10	3
Total	**18**	**35**	**52**	**33**	**46**	**26**

Table 59: Results for question 8 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 60).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	4	0.05	5.4	0.05	5.12	0.05
2	1	ns	0.11	ns	0	ns
3	4.45	0.05	0.36	ns	6.25	0.05
4	0.18	ns	0.29	ns	0	ns
5	0.08	ns	0.22	ns	1	ns
All Participants	**4.41**	**0.05**	**1.49**	**ns**	**8.67**	**0.01**

Table 60: Chi-squared results for difference between status 1 and status 2.

Table 60 shows a significant difference in the total number of correct and "don't knows" answered between status 1 and 2. These results demonstrate that tutorial 2 has had a positive effect on participants. Although a small increase in wrong answers in observed in Table 59, this was found not to be significant which further supports the positive effect of tutorial 2.

Significant increases were found for correct and wrong answers between status 1 and 2 for level 1. This suggests participants have gained false confidence.

No significant differences have been observed for level 2. Although an increase is observed in the number of correct answers between status 1 and 2, this was not found to be significant. These results may be due the small sample size.

Level 3 show the only significant positive results as the number of correct answers increased and the number of "don't knows" has decreased between status 1 and 2.

No significant results have been observed for levels 4 and 5. This may be due to the high results observed in status 1. The room for improvement was therefore limited and although an increase in correct answers can be seen for level 5, results found no significant differences.

This question relied on participants knowing specific features on the perinatal pubis. Overall results for this question improved. However, as there were limited improvements observed in individual levels this area would be readdressed in the future. More labelling activities would be available in addition to more features being highlighted on the 3D animation.

Question 9

"The billowed appearance of the arrowed surface indicates…"

Possible answers: the bone is fully matured, **the bone is still growing**, the bone shows pathology on the iliac crest or don't know.

Table 61 indicates the results from question 9, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct answers have increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on participants.

All levels (except level 4) show an increase in correct answers, however an increase in wrong answers is also observed in level 1 results. Level 4 shows no change as expected as there is 100% accuracy in status 1 and 2.

Level	**Status 1**			**Status 2**		
	Correct	**Wrong**	**Don't know**	**Correct**	**Wrong**	**Don't know**
1	6	3	17	19	4	3
2	6	2	6	13	0	1
3	6	5	15	23	2	1
4	19	0	0	19	0	0
5	13	1	6	20	0	0
Total	**50**	**11**	**44**	**94**	**6**	**5**

Table 61: Results for question 9 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 62).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	6.76	0.05	0.14	ns	9.8	0.01
2	5.58	ns	2	ns	3.57	ns
3	9.97	0.01	1.29	ns	12.25	0.001
4	0	ns	0	ns	0	ns
5	1.48	ns	1	ns	6	0.05
All Participants	**13.44**	**0.001**	**1.47**	**ns**	**31.04**	**0.001**

Table 62: Chi-squared results for difference between status 1 and status 2.

Table 62 shows a significant difference in the total number of correct and "don't knows" answered between status 1 and 2. These results demonstrate that tutorial 2 has had a positive effect on participants.

Level 1 and 3 show significant improvement between status 1 and 2 as the number of correct answers increased significantly whilst the number of "don't knows" answered decreased significantly.

No significant differences have been observed for level 2. Although an increase is observed in the number of correct answers between status 1 and 2, this was not found to be significant. These results may be due to the small sample size.

No significant results have been observed for levels 4. This may be due to the high results observed in status 1. The room for improvement was therefore limited.

A significant decrease in "don't knows" has been observed for level 5. Although no significant difference has be demonstrated by the increase in correct answers, it can be seen that in status 2, all

participants in level 5 obtained the correct answer, therefore sample size may have been the cause.

The content of this question was addressed in tutorial 2 through image and text description. As there was a significant improvement for all participants together and increases were observed for all levels individually this method was successful. However, in the future it could be suggested that sound recordings would be included to give participants the option to read or listen as this may engage the learner and attract different learning styles. Having these options will give students more freedom, but also may increase understanding through addressing different learning styles.

Question 10 - Multiple choice

"Secondary ossification in the innominate is generally seen in which region first?"

Possible answers: **acetabulum**, iliac crest, pubic symphysis, anterior inferior iliac spine.

Table 63 indicates the results from question 10, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2. However, a larger increase in the number of wrong answers compared to the number of correct answers between status 1 and 2 is observed. This suggests participants have not learned the content of the question during completion of tutorial 2. Although all levels individually show an increase in correct answers, a larger increase in wrong answers is observed further supporting the content of the question was not learned.

Level	Status 1			Status 2		
	Correct	Wrong	Don't know	Correct	Wrong	Don't know
1	0	1	25	7	12	7
2	0	3	11	8	4	2
3	2	1	23	4	16	6
4	12	1	6	13	6	0
5	5	6	9	9	10	1
Total	**19**	**12**	**74**	**41**	**48**	**16**

Table 63: Results for question 10 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 64).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	7	0.01	9.31	0.01	10.13	0.001
2	8	0.01	0.14	ns	6.23	0.05
3	0.67	ns	13.24	0.001	9.97	0.01
4	0.04	ns	3.57	ns	6	0.05
5	1.14	ns	1	ns	6.4	0.05
All Participants	**8.07**	**0.01**	**21.6**	**0.001**	**37.38**	**0.001**

Table 64: Chi-squared results for difference between status 1 and status 2.

Table 64 shows a significant difference in the total number of correct and "don't knows" answered between status 1 and 2. These results demonstrate that tutorial 2 has had a positive effect on participants, however the increase in wrong answers between status 1 and 2 is of higher significance. Therefore the content of the question has not been understood following completion of tutorial 2.

Significant increases were found for correct and wrong answers between status 1 and 2 for level 1. This suggests participants have gained false confidence.

Significant differences have been observed for the number of correct answers between status 1 and 2 for level 2. Although an increase is observed in the number of wrong answers between status 1 and 2, this was not found to be significant therefore concluding that a positive effect has been observed for level 2.

Level 3 show a significant difference in the number of wrong answers between status 1 and 2. This suggests tutorial 2 has given level 3 false understanding or false confidence.

No significant results have been observed for levels 4 and 5. However, results from Table 63 suggest a negative effect.

This particular question is complex; it requires participants to know the timing of all aspects of secondary ossification of the innominate. Results suggest participants have gained confidence in answering the question (as the number of "don't knows" has decreased) but have not gained the knowledge required to answer the question.

The content of this question was addressed throughout the tutorial. In the future, more interactive activities may aid students to learn the sequence of development.

Question 11 - Multiple choice

"The head of the femur is an example of a secondary centre of ossification. The shaft of the femur forms from a ***primary*** *centre os ossification?"*

Possible answers: **primary**, secondary, tertiary or don't know.

Table 65 indicates the results from question 11, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct answers have increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on participants. However, a small increase in wrong answers is also observed.

Between status 1 and 2 level 1, 2 and 5 show an increase in wrong answers and correct answers, drawing no conclusions about participants understanding of the content. Results from Level 3 indicate that tutorial 2 has had a positive effect. Level 4 shows no change as expected as there is 100% accuracy in status 1 and 2.

Level	**Status 1**			**Status 2**		
	Correct	**Wrong**	**Don't know**	**Correct**	**Wrong**	**Don't know**
1	5	2	19	14	10	2
2	7	3	4	8	4	2
3	20	2	4	26	0	0
4	19	0	0	19	0	0
5	14	1	5	17	3	0
Total	**65**	**8**	**32**	**84**	**17**	**4**

Table 65: Results for question 11 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 66).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	4.26	0.05	5.33	0.05	13.76	0.001
2	0.07	ns	0.14	ns	0.67	ns
3	0.78	ns	2	ns	4	0.05
4	0	ns	0	ns	0	ns
5	0.29	ns	1	ns	5	0.05
All Participants	**2.42**	**ns**	**3.24**	**ns**	**21.78**	**0.001**

Table 66: Chi-squared results for difference between status 1 and status 2.

Table 66 shows no significant differences in the total number of correct, and wrong answered between status 1 and 2. These results show that tutorial 2 has not had a positive effect on participants as they have not demonstrated that they have learned the content of the question following completion of tutorial 2.

Significant increases were found for correct and wrong answers between status 1 and 2 for level 1. This suggests participants have gained false confidence.

No significant differences were observed for level 2. Although a small increase is observed in the number of correct answers between status 1 and 2, there was also a small increase in wrong answers, this was not found to be significant. These results may be due to the small sample size.

As expected, level 4 obtained the correct answer in status 1. In this case each participant in level 4 was correct in status 1 and their answer did not change by status 2, therefore no significant differences between status 1 and 2 were observed.

Although a significant decrease in "don't knows" was observed for level 5, there were no significant differences observed in correct or wrong answers between status 1 and 2, therefore full understanding of the content of the question has not been demonstrated.

Other than a brief introduction and an external link on the description of ossification, participants were not given a lot of information about the development of bones other than the innominate. In the future should the project continue into other regions of the skeleton, an introductory tutorial into ossification will be created and tested on students to ensure they understand the concept before continuing with specific areas of the skeleton.

Question 12 - Fill in the blank

*"A secondary centre of ossification can also be called an **epiphysis**."*

Table 67 indicates the results from question 12, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct answers have increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on participants. However, a small increase in wrong answers is also observed.

Level 1 and 2 show little improvement as the number of "don't knows" answers remains high in status 2. Level 3 appear to have improved the greatest, whilst the number of correct answers answered for level 5 has risen by 1. Level 4 shows no change as expected as there is 100% accuracy in status 1 and 2.

Level	Status 1			Status 2		
	Correct	Wrong	Don't know	Correct	Wrong	Don't know
1	0	0	26	3	5	18
2	0	0	14	2	3	9
3	2	2	22	15	2	9
4	17	1	1	17	1	1
5	9	2	9	10	2	8
Total	**28**	**5**	**72**	**47**	**13**	**45**

Table 67: Results for question 12 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 68).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	3	ns	5	0.05	1.45	ns
2	2	ns	3	ns	1.09	ns
3	9.94	0.01	0	ns	5.45	0.05
4	0	ns	0	ns	0	ns
5	0.05	ns	0	ns	0.06	ns
All Participants	**4.81**	**0.05**	**3.56**	**ns**	**6.23**	**0.05**

Table 68: Chi-squared results for difference between status 1 and status 2.

Table 68 shows a significant difference in the total number of correct and "don't knows" answered between status 1 and 2. These results demonstrate that tutorial 2 has had a positive effect on participants. Although an increase in wrong answers between status 1 and 2 can be observed, this was not found to be significant.

Level 1 show a significant increase in the number of wrong answers answered between status 1 and 2. This indicates the majority of these participants did not learn the content of the question. As the number of "don't knows" answered between status 1 and 2 does not change significantly, this suggests that participants are not gaining the confidence to answer the question correctly.

Similar results for level 2 can be observed in Table 67 for level 2. These however have not been found to be significant. As the number of "don't knows" answered between status 1 and 2 remains high it can be suggested that participants neither learned the content of the question from tutorial 2 or gained the confidence to answer the question correctly.

Level 3 show the only significant improvement as the number of correct answers increased whilst the number of "don't knows" decreased between status 1 and 2.

No significant results have been observed for level 4. This may be due to the high results expected and observed in status 1. The room for improvement was therefore limited.

Level 5 also show no significant results. As the number of "don't knows" answered between status 1 and 2 remains relatively constant it can be suggested that participants neither learned the content of the question from tutorial 2 or gained the confidence to answer it.

It would be expected that the majority of participants would learn this information as it was mentioned throughout tutorial 2. However if participants did not understand the concept initially they may not gain the knowledge. In the future should the project continue into other regions of the skeleton, an introductory tutorial into ossification

would be created to ensure students understand the concept before continuing onto specific areas of the skeleton.

Question 13 - True / False

"The iliac crest generally forms from a single centre of ossification."
Possible answers: true, **false** or don't know

Table 69 indicates the results from question 13, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct answers have increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on participants. However, a small increase in wrong answers is also observed.

Level 1, 2 and 3 all show an increase in correct and wrong answers, suggesting not all participants learned the content of the question. Level 4 shows no change as expected as there is 100% accuracy in status 1 and 2. Level 5 are the only levels that showed improvement, as correct answers increased and wrong answers did not.

Level	**Status 1**			**Status 2**		
	Correct ("true")	**Wrong ("false")**	**Don't know**	**Correct ("true")**	**Wrong ("false")**	**Don't know**
1	3	1	22	12	10	4
2	0	5	9	6	6	2
3	4	6	16	16	8	2
4	19	0	0	19	0	0
5	9	3	8	16	3	1
Total	**35**	**15**	**55**	**69**	**27**	**9**

Table 69: Results for question 13 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 70).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	5.4	0.05	7.36	0.01	12.46	0.001
2	6	0.05	0.09	ns	4.45	0.05
3	7.2	0.01	0.29	ns	10.89	0.001
4	0	ns	0	ns	0	ns
5	1.96	ns	0	ns	5.44	0.05
All Participants	**11.12**	**0.001**	**3.43**	**ns**	**33.06**	**0.001**

Table 70: Chi-squared results for difference between status 1 and status 2.

Table 70 shows a significant difference in the total number of correct and "don't knows" answered between status 1 and 2. These results demonstrate that tutorial 2 has had a positive effect on participants. Although an increase in wrong answers between status 1 and 2 can be observed, this was not found to be significant.

Significant increases were found for correct and wrong answers between status 1 and 2 for level 1. This suggests participants have gained false confidence.

Improvements in results between status 1 and 2 for levels 2 and 3 were found to be significant. These results show that tutorial 2 had a positive effect.

No significant results have been observed for level 4 as status 1 and 2 show 100% correct answers.

Level 5 show a significant difference in the number of "don't knows" answered between status 1 and 2. Although no significant differences have been reported for the number of correct or wrong answers, an increase in correct answers is observed. This suggests a positive effect, however due to sample size the results were not found to be significant.

The content of this particular question was explained through text only. The iliac crest was pictured as one centre of ossification, however it actually forms from 2 centres which fuse to each other before fusing to the body of the ilium. This question required participants to have read this information. Overall there was a significant increase in correct answers which suggests the majority of participants understood the content, however the response rate could be improved by enhancing with visual support.

Question 14 - Multiple choice

"Which is the more mature specimen?
Possible answers: 1, **2** or don't know

Table 71 indicates the results from question 14, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct answers have increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on participants.

Level 1, 2, 3 and 5 all show an increase in correct answers. Level 4 shows no change as expected as there is 100% accuracy in status 1 and 2.

Level	Status 1			Status 2		
	Correct	Wrong	Don't know	Correct	Wrong	Don't know
1	16	3	7	23	2	1
2	9	2	3	13	0	1
3	13	6	7	20	5	1
4	19	0	0	19	0	0
5	16	3	1	19	1	0
Total	**73**	**14**	**18**	**94**	**8**	**3**

Table 71: Results for question 14 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 72).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	1.26	ns	0.2	ns	4.5	0.05
2	0.73	ns	2	ns	1	ns
3	1.48	ns	0.09	ns	4.5	0.05
4	0	ns	0	ns	0	ns
5	0.26	ns	1	ns	1	ns
All Participants	**2.64**	**ns**	**1.64**	**ns**	**10.71**	**0.01**

Table 72: Chi-squared results for difference between status 1 and status 2.

Table 72 shows no significant differences in the total number of correct, and wrong answers answered between status 1 and 2. Although there is a significant decrease in the number of "don't knows" answered, as there is no significant changes in correct and wrong answers, there is no reason to state that the decrease was due to a positive effect from tutorial 2. As there was no change observed

it could be suggested that tutorial 2 has not had a positive effect on participants as they have not demonstrated that they have learned the content of the question following completion of tutorial 2.

The only significant differences observed were seen in the number of "don't knows" answered between status 1 and 2 for levels 1 and 3. However, these results do not demonstrate the effect of the tutorial as there are no significant changes between status 1 and 2 for correct or wrong answers. Although there is an increase in correct answers for levels 1, 2, 3 and 5, none were found to be significant. This may be due to small sample sizes, however the correct answers in status 1 is relatively high, therefore leaving little room for improvement.

No significant results have been observed for level 4 as status 1 and 2 show 100% correct answers.

This question required participants to use the knowledge they gained throughout tutorial 2 to answer the question. As observed in Table 71 there are high results in status 1, which suggests participants had the information prior to completing tutorial 2. In the future, more aging activities would be included to ensure all participants understand the development of each region of the skeleton.

Question 15 - Multiple choice

*"The ischial epiphysis extends anteriorly to form the **ramal** epiphysis."*

Possible answers: tuberosity, **ramal**, pubic or don't know

Table 73 indicates the results from question 15, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct answers has increased between status 1 and 2.

These results suggest tutorial 2 has had a positive effect on participants. However, a small increase in wrong answers is also observed.

Level 1, 2 and 5 all show an increase in correct and wrong answers, suggesting not all participants learned the content of the question. Level 3 show improvement as the number of correct answers increased. Level 4 shows no change as expected as there is 100% accuracy in status 1 and 2.

Level	**Status 1**			**Status 2**		
	Correct	**Wrong**	**Don't know**	**Correct**	**Wrong**	**Don't know**
1	1	3	22	13	7	6
2	1	2	11	7	4	3
3	2	7	17	15	7	4
4	14	3	2	16	3	0
5	8	6	6	10	8	2
Total	**26**	**21**	**58**	**61**	**29**	**15**

Table 73: Results for question 15 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 74).

	Correct		**Wrong**		**Don't know**	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	10.29	0.01	1.6	ns	9.14	0.01
2	4.5	0.05	0.67	ns	4.54	0.05
3	9.94	0.01	0	ns	8.05	0.01
4	0.13	ns	0	ns	2	ns
5	0.22	ns	0.29	ns	2	ns
All Participants	**14.08**	**0.001**	**1.28**	**ns**	**25.33**	**0.001**

Table 74: Chi-squared results for difference between status 1 and status 2.

Table 74 shows a significant difference in the total number of correct and "don't knows" answered between status 1 and 2. These results demonstrate that tutorial 2 has had a positive effect on participants. Although an increase in wrong answers between status 1 and 2 can be observed, this was not found to be significant.

Improvements in results between status 1 and 2 have been demonstrated by level 1, 2 and 3 were found to be significant. These results show that tutorial 2 had a positive effect on result.

No significant differences have been observed for level 4. This may be due to the high results expected and observed in status 1. The room for improvement was therefore limited.

No significant differences were found for the results of level 5 participants. An increase in correct and wrong answers can be seen in Table 73 which suggests participants require more information for further understanding.

Question 15 was addressed through text, image and drag and drop activities within tutorial 2. The success of these results suggests that participants have understood the content and that this is an effective example of utilising a number of methods for delivery of academic content. In the future sound could also be included in order to address more learning styles for increased understanding.

Question 16 - Multiple choice

"This centre of ossification can form from an upwards projection of which epiphysis of the acetabulum?"

Possible answers: os acetabuli, **superior**, posterior, inferior or don't know.

Table 75 indicates the results from question 16, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct and wrong answers have increased between status 1 and 2. This suggests a possible lack of understanding or over confidence and this area may require further consideration.

Level 1, 2, 3 and 5 all show an increase in correct and wrong answers, suggesting not all participants learned the content of the question. Level 4 shows no change as expected as there is a high accuracy in status 1 and 2.

Level	**Status 1**			**Status 2**		
	Correct	**Wrong**	**Don't know**	**Correct**	**Wrong**	**Don't know**
1	0	1	25	2	10	14
2	1	3	10	2	5	7
3	1	2	23	13	8	5
4	16	1	2	17	2	0
5	3	4	13	10	5	5
Total	**21**	**11**	**73**	**44**	**30**	**31**

Table 75: Results for question 16 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 76).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	2	ns	7.36	0.01	3.1	ns
2	0.33	ns	0.5	ns	0.53	ns
3	10.29	0.01	3.6	ns	11.97	0.001
4	0.03	ns	0.33	ns	2	ns
5	3.77	ns	0.11	ns	3.56	ns
All Participants	**8.14**	**0.01**	**8.8**	**0.01**	**16.96**	**0.001**

Table 76: Chi-squared results for difference between status 1 and status 2.

Table 76 shows a significant difference in the total number of correct and wrong answers answered between status 1 and 2. These results demonstrate that tutorial 2 has given participants the confidence to answer the question, however, a number of participants did not gain the knowledge required to answer the question correctly.

Level 1 showed a significant increase in wrong answers between status 1 and 2. This demonstrates that participants did not understand the information required to answer the question.

No significant differences were observed for level 2. Results from Table 75 suggest participants are not gaining the knowledge from tutorial 2 to answer the question.

Level 3 show the only significant improvement as the number of correct answers has increased and the number of "don't knows" answered had decreased between status 1 and 2.

No significant differences have been observed for level 4. This may be due to the high results expected and observed in status 1. The room for improvement was therefore limited.

No significant differences were found for the results of level 5 participants. An increase in correct and wrong answers can be seen in Table 75 which suggests participants require more information for further understanding.

The question requires detailed knowledge and understanding of the development of the innominate. The content was addressed through text and images within tutorial 2. Results overall did not demonstrate complete understanding, therefore this area should be readdressed in the future. Labelling activities, with highlights may aid participants, as would the inclusion of sound and 3D animations.

Question 17 - Multiple choice

"Assign an age to this specimen."

Perinate, 10-20 years, **21-30 years**, 30+ years or don't know

Table 77 indicates the results from question 17, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct and wrong answers have increased between status 1 and 2. This suggests lack of understanding and this area may require further consideration.

Level 1 and 3 showed an increase in correct and wrong answers, suggesting not all participants learned the content of the question. Level 2, 4 and 5 show improvement as the number of correct answers has increased whilst the number of wrong answers has decreased.

Level	Status 1			Status 2		
	Correct	Wrong	Don't know	Correct	Wrong	Don't know
1	0	2	24	6	18	2
2	1	5	8	9	4	1
3	1	5	20	14	10	2
4	4	8	7	13	6	0
5	3	11	6	11	9	0
Total	**9**	**31**	**65**	**53**	**47**	**5**

Table 77: Results for question 17 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 78).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	6	0.05	12.8	0.001	18.62	0.001
2	6.4	0.05	0.11	ns	5.44	0.05
3	11.27	0.001	1.67	ns	14.73	0.001
4	4.76	0.05	0.29	ns	7	0.01
5	4.57	0.05	0.2	ns	6	0.05
All Participants	**31.23**	**0.001**	**3.28**	**ns**	**51.43**	**0.001**

Table 78: Chi-squared results for difference between status 1 and status 2.

Table 78 shows a significant difference in the total number of correct and "don't knows" answered between status 1 and 2. These results demonstrate that tutorial 2 has had a positive effect on participants. Although an increase in wrong answers between status 1 and 2 can be observed, this was not found to be significant.

Significant increases were found for correct and wrong answers between status 1 and 2 for level 1. This suggests participants have gained false confidence.

Improvements in results between status 1 and 2 have been demonstrated by levels 2-5. These were found to be significant. These results show that tutorial 2 had a positive effect on result.

This particular question requires participants to understand the complex sequence of timing of all aspects of the development of the innominate. Results suggest a significant number of participants have gained the knowledge required to answer this question.

Question 18 - True / False

"The epiphysis for the pubic tubercle can be formed from a projection of the inferior ossific nodule."

Possible answers: true, **false** or don't know.

Table 79 indicates the results from question 18, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct and wrong answers have increased between status 1 and 2. This suggests lack of understanding and this area may require further consideration.

No individual levels show improvement as the number of wrong answers increased for all levels.

Level	Status 1			Status 2		
	Correct ("true")	Wrong ("false")	Don't know	Correct ("true")	Wrong ("false")	Don't know
1	1	1	24	6	3	17
2	3	1	10	3	4	7
3	2	1	23	7	7	12
4	7	3	9	12	5	2
5	1	4	15	6	8	6
Total	**14**	**10**	**81**	**34**	**27**	**44**

Table 79: Results for question 18 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 80).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	3.57	ns	1	ns	1.2	ns
2	0	ns	1.8	ns	0.53	ns
3	2.78	ns	4.5	0.05	3.46	ns
4	1.32	ns	0.5	ns	4.45	0.05
5	3.57	ns	1.33	ns	3.86	0.05
All Participants	**8.33**	**0.01**	**5.26**	**0.05**	**32.01**	**0.001**

Table 80: Chi-squared results for difference between status 1 and status 2.

Table 80 shows a significant difference in the total number of correct and wrong answers answered between status 1 and 2. These results demonstrate that tutorial 2 had a positive effect on participants, however a significant difference was also observed for the number of wrong answers answered between status 1 and 2. Therefore it

cannot be determined that an overall positive effect has been observed.

No significant differences have been observed for the number of correct or wrong answers answered between status 1 and 2 for levels 1-5. These results suggest this particular content should be readdressed as participants did not show any significant sign of gaining the knowledge required to answer the question correctly.

In the future, an animation of the maturation of the pubic symphysis would be created. This is a complex area to understand and for this project the content was addressed though text and 2D images. A 3D animation with sound may aid the learner gain the knowledge required to answer the question.

Question 19 - Multiple choice

"Which types of cartilage are involved in the growth of the acetabulum"

Possible answers: **growth**, auricular, **articular**, **epiphyseal** or don't know.

Participants gained one mark for each correct answer, however, for analysis, participants not obtaining full marks have been marked as wrong. This method may highlight areas where participants do not understand the content of the question fully.

Table 81 indicates the results from question 19, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct and wrong answers have increased between status 1 and 2. This suggests lack of understanding and this area may require further consideration.

No individual levels show improvement as the number of correct and wrong answers have increased between status 1 and 2.

Level	Status 1			Status 2		
	Correct (3/3)	Wrong (0,1,2/3)	Don't know	Correct (3/3)	Wrong (0,1,2/3)	Don't know
1	0	3	23	7	12	7
2	0	2	12	7	5	2
3	0	11	15	8	16	2
4	7	8	4	9	9	1
5	1	11	8	4	15	1
Total	**8**	**35**	**62**	**35**	**57**	**13**

Table 81: Results for question 19 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 82).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	7	0.01	5.4	0.05	8.53	0.01
2	7	0.01	1.29	ns	7.14	0.01
3	8	0.01	0.93	ns	9.94	0.01
4	0.25	ns	0.06	ns	1.8	ns
5	1.8	ns	0.62	ns	5.44	0.05
All Participants	**16.95**	**0.001**	**5.26**	**0.05**	**32.01**	**0.001**

Table 82: Chi-squared results for difference between status 1 and status 2.

Table 82 shows a significant difference in the total number of correct and wrong answers answered between status 1 and 2. These results demonstrate that tutorial 2 had a positive effect on participants, however a significant difference was also observed for the number of

wrong answers answered between status 1 and 2. Therefore it cannot be determined that a positive effect has been observed.

Significant increases were found for correct and wrong answers between status 1 and 2 for level 1. This suggests participants have gained false confidence. However, the significance value for correct answers is higher that that for the wrong answers which suggests the content has been understood by a higher number of participants from this level.

Improvements in results between status 1 and 2 have been demonstrated by levels 2 and 3 were found to be significant. These results show that tutorial 2 had a positive effect on result.

No significant differences have been observed for level 4 and 5. As there is room for improvement, these results suggest participants have not learned the content of the question from tutorial 2.

This particular question was addressed by text, 2D image and a 3D animation. Although the majority of participants gained at least one mark out of 3 for the question, the results from Table 81 show participants did not understand the content fully.

In the future, should the module continue into a course on skeletal development, types of cartilage would be addressed in an introductory chapter which would be a requirement prior to continuing with specific regions of the skeleton.

Question 20 - True / False

"The acetabular surface of the ilium, ischium and pubis are identifiable at birth."

Possible answers: **true**, false or don't know

Table 83 indicates the results from question 20, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct answers has increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on participants. However, a small increase in wrong answers is also observed.

All levels show improvement due to the increase in correct answers between status 1 and 2. A small increase in wrong answers is observed for levels 1-3.

Level	**Status 1**			**Status 2**		
	Correct ("true")	**Wrong ("false")**	**Don't know**	**Correct ("true")**	**Wrong ("false")**	**Don't know**
1	4	0	22	19	5	2
2	5	1	8	11	2	1
3	9	1	16	22	2	2
4	13	6	0	17	2	0
5	9	2	9	16	2	2
Total	**40**	**10**	**55**	**85**	**13**	**7**

Table 83: Results for question 20 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 84).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	9.78	0.01	5	0.05	16.67	0.001
2	2.25	ns	0.33	ns	5.44	0.05
3	5.45	0.05	0.33	ns	10.89	0.001
4	0.53	ns	2	ns	0	ns
5	1.96	ns	0	ns	4.45	0.05
All Participants	**16.2**	**0.001**	**0.39**	**ns**	**37.16**	**0.001**

Table 84: Chi-squared results for difference between status 1 and status 2.

Table 84 shows a significant difference in the total number of correct and "don't knows" answered between status 1 and 2. These results demonstrate that tutorial 2 had a positive effect on participants.

Significant increases were found for correct and wrong answers between status 1 and 2 for level 1. This suggests participants have gained false confidence. However, the significance value for correct answers is higher that that for the wrong answers which suggests the content has been understood by a higher number of participants in this level. Similar results for level 2 can be observed in Table 83. These however have not been found to be significant.

Improvements in results between status 1 and 2 demonstrated by level 3 were found to be significant. These results show that tutorial 2 had a positive effect on result.

No significant differences have been observed for level 4 and 5. As there is room for improvement, these results suggest participants have not learned the content of the question from tutorial 2.

Although a positive effect has been demonstrated by all overall participants, this was not observed at all levels. As the content of the question was not fully understood this area could be further addressed through labelling and 3D activities.

Question 21 - Multiple choice

"The first epiphysis to form in the region of the acetabulum appears between 9 and 10 years and extends to fuse with the ***anterior*** *flange of the triradiate."*

Possible answers: vertical, horizontal, **anterior**, posterior or don't know

Table 85 indicates the results from question 21, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct answers has increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on participants. However, an increase in wrong answers is also observed.

Level 1-3 and 5 show an increase in correct and wrong answers, suggesting limited understanding. Level 4 were the only level who showed improvements as the number of correct answers increased whilst the number of wrong answers decreased.

Level	Status 1			Status 2		
	Correct	Wrong	Don't know	Correct	Wrong	Don't know
1	0	2	24	10	11	5
2	1	1	12	8	3	3
3	0	4	22	7	14	5
4	8	5	6	17	2	0
5	5	0	15	8	10	2
Total	**14**	**12**	**79**	**50**	**40**	**15**

Table 85: Results for question 21 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 86).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	10.	0.01	6.23	0.05	12.45	0.001
2	5.44	0.05	1	ns	5.4	0.05
3	7	0.01	5.56	0.05	10.70	0.01
4	3.24	ns	1.29	ns	6	0.05
5	0.69	ns	10	0.01	9.94	0.01
All Participants	**20.25**	**0.001**	**15.08**	**0.001**	**43.57**	**0.001**

Table 86: Chi-squared results for difference between status 1 and status 2.

Table 86 shows a significant difference in the total number of correct and wrong answers answered between status 1 and 2. These results demonstrate that tutorial 2 has not given all participants the knowledge to answer question 21 accurately.

Significant increases were found for correct and wrong answers between status 1 and 2 for level 1. This suggests participants have gained false confidence. However, the significance value for correct answers is higher that that for the wrong answers which suggests the content has been understood by a higher number of participants in these levels. Similar results for level 4 can be observed in Table 85. These however have not been found to be significant.

Improvements in results between status 1 and 2 demonstrated by level 2 were found to be significant. These results show that tutorial 2 had a positive effect on result.

Level 5 show a significant increase in wrong answers between status 1 and 2. This suggests these participants have not learned the content required to answer the question.

The question requires detailed knowledge and understanding of the development of the innominate. This particular question was addressed by text, 2D image and a 3D animation. As results were not positive (due to the significant increase in wrong answers) participants demonstrated they did not understand the content fully. As this is a complex region of development, in the future should the module continue into a course on skeletal development, the 3D animation would include labels to highlight specific features.

Question 22 - Multiple choice

"Name the highlighted epiphysis of the acetabulum."

Possible answers: triradiate, **os acetabuli**, posterior epiphysis, superior epiphysis or don't know

Table 87 indicates the results from question 22, test 2 at each level for status 1 and status 2. It can be seen that overall the number of

"don't knows" has decreased between status 1 and 2 and the total number of correct answers has increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on participants.

Individual levels show improvement and weaknesses as the number of correct and wrong answers increased between status 1 and 2.

Level	**Status 1**			**Status 2**		
	Correct	**Wrong**	**Don't know**	**Correct**	**Wrong**	**Don't know**
1	0	1	25	13	8	5
2	3	4	7	6	3	5
3	2	4	20	19	6	1
4	13	6	0	19	0	0
5	3	6	11	19	1	0
Total	**21**	**21**	**63**	**76**	**18**	**11**

Table 87: Results for question 22 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 88).

	Correct		**Wrong**		**Don't know**	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	13	0.001	5.44	0.05	13.33	0.001
2	1	ns	0.14	ns	0.33	ns
3	13.76	0.001	0.4	ns	17.19	0.001
4	1.13	ns	6	0.05	0	ns
5	11.64	0.001	3.57	ns	11	0.001
All Participants	**31.19**	**0.001**	**0.23**	**ns**	**36.54**	**0.001**

Table 88: Chi-squared results for difference between status 1 and status 2.

Table 88 shows a significant difference in the total number of correct and "don't knows" answered between status 1 and 2. These results demonstrate that tutorial 2 had a positive effect on participants.

Level 1 showed significant increases for correct and wrong answers between status 1 and 2. The significance value for correct answers is higher that that for the wrong answers which suggests the content has been understood by a higher number of participants in this level. Similar results for level 2 can be observed in Table 88. These however have not been found to be significant.

Improvements in results between status 1 and 2 have been demonstrated by levels 3 and 5 were found to be significant. These results show that tutorial 2 had a positive effect on result.

Improvements have also been observed by level 4 as the number of wrong answers has significantly decreased. This also supports that tutorial 2 has had a positive effect on results.

The content of this question was addressed through text and images within tutorial 2. Results demonstrated understanding however in the future to improve this area, labelling activities with highlights may aid participants, as might the inclusion of sound and 3D animations.

Question 23 - Multiple choice

"Which epiphysis does not extend into the triradiate region?"

Possible answers: posterior epiphysis, os acetabuli, **superior epiphysis** or don't know.

Table 89 indicates the results from question 23, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total

number of correct answers has increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on participants. However, an increase in wrong answers is also observed.

Level 1 and 3 show an increase in correct and wrong answers, suggesting limited understanding. Level 2, 4 and 5 showed improvements as the number of correct answers increased whilst the number of wrong answers decreased.

Level	**Status 1**			**Status 2**		
	Correct	**Wrong**	**Don't know**	**Correct**	**Wrong**	**Don't know**
1	0	1	25	10	7	9
2	0	3	11	6	4	4
3	0	5	21	9	12	5
4	12	4	3	14	5	0
5	3	3	14	12	5	3
Total	**15**	**16**	**74**	**51**	**33**	**21**

Table 89: Results for question 23 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 90).

	Correct		**Wrong**		**Don't know**	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	10	0.01	4.5	0.05	7.53	0.01
2	6	0.05	0.14	ns	3.27	ns
3	9	0.01	2.88	ns	9.85	0.01
4	0.15	ns	0.11	ns	3	ns
5	5.4	0.05	0.5	ns	7.12	0.01
All Participants	**19.64**	**0.001**	**5.9**	**0.05**	**29.57**	**0.001**

Table 90: Chi-squared results for difference between status 1 and status 2.

Table 90 shows a significant difference in the total number of correct and wrong answers answered between status 1 and. These results demonstrate that tutorial 2 had a positive effect on participants, however a significant difference was also observed for the number of wrong answers answered between status 1 and 2. However, the significance value for correct answers is higher that that for the wrong answers which suggests the content has been understood by a higher number of participants.

Significant increases were found for correct and wrong answers between status 1 and 2 for level 1. This suggests participants have gained false confidence. However, the significance value for correct answers is higher that that for the wrong answers which suggests the content has been understood by a higher number of participants in this level. Similar results for level 4 can be observed in Table 89. These however have not been found to be significant.

Improvements in results between status 1 and 2 have been demonstrated by levels 2, 3 and 5 were found to be significant. These results show that tutorial 2 had a positive effect on result.

The content of this question was addressed through text and images within tutorial 2. Results overall did not demonstrate complete understanding, therefore this area should be readdressed in the future. Labelling activities, with highlights may aid participants, as would the inclusion of sound and 3D animations.

Question 24 - Drag and drop

"This triradiate cartilage is ossifying. Label each flange."

This drag and drop question used an image of a right innominate. Participants were asked to label each flange (**anterior, posterior, vertical**).

Participants gained one mark for each correct answer, however, for analysis, participants not obtaining full marks have been marked as wrong. This method may highlight areas where participants do not understand the content of the question fully.

Table 91 indicates the results from question 24, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct answers has increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on participants. All levels show signs of improvement, however level 1 also shows a small increase in wrong answers.

Level	**Status 1**			**Status 2**		
	Correct (3/3)	**Wrong (0,1,2/3)**	**Don't know**	**Correct (3/3)**	**Wrong (0,1,2/3)**	**Don't know**
1	0	5	21	12	6	8
2	0	3	11	10	2	2
3	6	2	18	23	2	1
4	17	1	1	18	1	0
5	7	3	10	17	0	3
Total	**30**	**14**	**61**	**80**	**11**	**14**

Table 91: Results for question 24 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 92).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	12	0.001	0.09	ns	5.83	0.05
2	10	0.01	0.2	ns	6.23	0.05
3	9.97	0.01	0	ns	15.21	0.001
4	0.03	ns	0	ns	1	ns
5	4.17	0.05	3	ns	3.77	ns
All Participants	**22.73**	**0.001**	**0.36**	**ns**	**29.45**	**0.001**

Table 92: Chi-squared results for difference between status 1 and status 2.

Table 92 shows a significant difference in the total number of correct and "don't knows" answered between status 1 and 2. These results demonstrate that tutorial 2 had a positive effect on participants.

Improvements in results between status 1 and 2 have been demonstrated by levels 1, 2, 3 and 5 were found to be significant. These results show that tutorial 2 had a positive effect on result.

No significant results have been observed for level 4. This may be due to the high results expected and observed in status 1. The room for improvement was therefore limited.

This particular question was addressed using text, 2D images and a 3D animation. As results showed understanding from all levels, these methods of teaching could be described as successful. However, in the future labels and highlights would be included on the 3D animation for completeness.

Question 25 - True / False

"The Os acetabuli has been highlighted?"

Possible answers: true, **false** or don't know.

Table 93 indicates the results from question 25, test 2 at each level for status 1 and status 2. It can be seen that overall the number of "don't knows" has decreased between status 1 and 2 and the total number of correct answers has increased between status 1 and 2. These results suggest tutorial 2 has had a positive effect on participants. However, an increase in wrong answers is also observed.

Level 1, 2, 3 and 5 show an increase in correct and wrong answers, suggesting limited understanding. Level 4 show a small increase in wrong answers. These results suggest limited understanding from all levels.

Level	**Status 1**			**Status 2**		
	Correct ("true")	**Wrong ("false")**	**Don't know**	**Correct ("true")**	**Wrong ("false")**	**Don't know**
1	0	3	23	7	14	5
2	0	6	8	5	7	2
3	2	3	21	8	17	1
4	11	7	1	11	8	0
5	4	2	14	11	9	0
Total	**17**	**21**	**67**	**42**	**55**	**8**

Table 93: Results for question 25 (all levels, all participants).

Chi-squared calculations were carried out to assess the significance of any differences displayed between responses in status 1 and status 2 (Table 94).

	Correct		Wrong		Don't know	
Level	**Chi-square**	**p**	**Chi-square**	**p**	**Chi-square**	**p**
1	7	0.01	7.12	0.01	11.57	0.001
2	5	0.05	0.08	ns	3.6	ns
3	3.6	ns	9.8	0.01	18.18	0.001
4	0	ns	0.07	ns	1	ns
5	3.27	ns	4.45	0.05	14.00	0.001
All Participants	**10.59**	**0.01**	**15.21**	**0.001**	**46.41**	**0.001**

Table 94: Chi-squared results for difference between status 1 and status 2.

Table 94 shows a significant difference in the total number of correct and wrong answers answered between status 1 and 2. These results demonstrate that tutorial 2 had a positive effect on participants, however a significant difference was also observed for the number of wrong answers answered between status 1 and 2. This significance value is higher that that for the correct answers which suggests the content has not been understood by a higher number of participants.

Significant increases were found for correct and wrong answers between status 1 and 2 for level 1. This suggests participants have gained false confidence.

Improvements in results between status 1 and 2 have been demonstrated and found to be significant by level 2 only.

Level 3 and 5 show significant weaknesses as the number of wrong answers increase between status 1 and 2.

No significant differences have been observed for level 4. As there is room for improvement, theses results suggest participants have not learned the content of the question from tutorial 2.

The content of this question was addressed through text and images within tutorial 2. Results overall did not demonstrate complete understanding, therefore this area could be readdressed in the future. Labelling activities, with highlights may aid participants, as might the inclusion of sound and 3D animations.

Conclusion of test 2 analysis

Overall, it can be stated that tutorial 2 was successful. Scores increased for all levels and these were found to be significant for levels 1-3 and 5.

Level 1 show a large increase in score between status 1 and 2, however, the average score by status 2 was under 50% which is below the pass rate for their degree. As these participants had limited knowledge of the adult skeleton, learning the development of a particular region would have been challenging. In addition to learning the pattern and sequence of the development of the innominate, they also had to come to grips with a new language in order to understand many concepts.

As the total number of "don't knows" answered in test 2 decreased significantly, it can be said that although these participants were not obtaining the correct answer, they were more confident to answer the questions by status 2, as seen by the decrease in "don't knows" from each question.

Level 2 show a similar decrease in "don't knows" answered between status 1 and 2, which also suggests improved confidence. Their score also showed that tutorial 2 had improved their knowledge on the development of the skeleton, however the average pass mark in status 2 was just over 50% which is below the grade required to

remain in their current degree. However, this level also had limited knowledge of the adult skeleton and required the knowledge of anatomical terminology.

Level 3 already had the knowledge of anatomical terminology prior to completing status 1 of test 2. Their improvements reflected this as their status 1 score was higher than that of level 1 and 2, and their status 2 score was around the average required to continue their current degree.

As level 4 had previously completed a face-to-face module in human osteology, their results were high in status 1 and remained relatively constant for status 2. As these participants have experience with the real specimens, their contribution to the evaluation of the module will be extremely beneficial, however the assessment data collected from them has cannot be used to determine the effectiveness of the online module.

Level 5 consist of staff and postgraduate students with mixed backgrounds in human osteology. Their scores largely mimicked that of level 3, as they improved up to the pass mark required.

Although test scores between status 1 and 2 have improved (Figure 35), the chi-squared analyses on individual questions have highlighted a number of weaknesses which might benefit from attention should the online tutorial continue.

These weaknesses will be addressed with the evaluations (in the next part) to discover if participants found weaknesses in the same areas discussed above.

4.1.3: Discussion of Questions

Each question related to the material contained in the main body of the tutorials (including the glossary), they were not based on the external links as these were for further reading. The questions required understanding to gain the correct answer rather than requiring full explanations of an entire concept.

Although in Chapter 4.1 (Part 1 and 2) a number of questions have stated that participants were not understanding the content and this may have caused low scores in status 2, there is nothing to suggest these questions were not understood by participants. Complex questions which often included anatomical terminology may have been difficult to understand if participants had little background knowledge of the subject. Also badly worded or long questions may have led to problems.

However, this cannot be reported as there is no evidence to support or refute that participants did not understand the question being asked rather than not understanding the content required to answer the question. It may have been useful to include a question in the evaluation relating to question styles. The format of the questions was only mentioned by one individual in the "any comments" section of the evaluation which stated some questions were "too long."

Questions were addressed through a number of templates available from the assessment software Questionmark™Perception™. This software program has various question types in which a number were utilised for assessing "Developmental Osteology."

Multiple choice

Multiple choice questions give users an answer choice, they do not have to think of the word, they can choose from a list. A number of questions in test 1 and 2 used these and overall answers improved however, in cases where participants had the option to choose more than one correct answer, full marks were not always awarded.

Having a choice of answers can give users the inclination to guess as there is a chance they can get it right. Although participants were asked not to guess, there was nothing to prevent them from doing so.

True / False, Yes / no

True or false (and yes / no) questions also give users the answer, they do not have to describe a term or remember a meaning of a word, the option is there to state if a statement is right or wrong. In a similar way to the multiple choice question, although there was the option to answer "don't know" there was nothing to stop users guessing.

Fill in the blank

This question type relies on users knowing the information and often requires recall of a specific term. If users do not know the answer to the question, it is difficult to guess.

A high number of "don't knows" in status 2 has been observed for some of these questions (Chapter 4.1.1 and 4.1.2). This shows that participants have tended not to guess and have left the question blank if they did not know the answer.

Spelling is also an issue when it comes to using fill in the blank questions, however this was rarely the case for questions answered

here. Questionmark™Perception™ allows a number of possible answers for this type of question to allow for spelling mistakes; this however was not put in place for this project.

Although this question type has not shown great improvements between stats 1 and 2, the question is a direct reflection of what a participant knows. However, this may also be due to confidence, where participants not answering the question are not confident in answering it due to not wanting to get the answer or spelling wrong.

In the future this question type would be considered, but may be introduced during the module to give users practice.

Drag and drop

This question type was extremely useful as it was a visual, interactive task for participants. Drag and drop features were also used throughout the tutorials and were noted to be extremely helpful to participants as they suggested adding more would improve the module (Chapter 4.2). Therefore it can be assumed that this type of question is useful for revision purposes.

Feedback was not given for any of the questions in test 1 or 2 as it may have affected status 2 results. As participants received the same test at status 1 and 2, if they were given feedback initially, they may have learned the information before tutorial 2. Although participants were not told they were getting the same test, it was decided that they should not be given the answers following completion of status 1. However, feedback should have been given following completing of status 2, but was not. In the future feedback would be given as it would indicate to users where they were going wrong and what they could do to improve.

There was no specific question type which did not suit this project. Other than some of the fill in the blank questions leaving relatively high numbers of "don't knows" in status 2, there were few others which caused problems. Questions which list possible answers seem to show the largest improvement and, although this method can elicit guessed answers, it can also improve confidence as users do not have to recall a specific answer. A mixture of question types may keep the participant engaged and the inclusion of images may aid in testing the visual subject.

4.2: Evaluation of the approach

In addition to establishing the effectiveness of the module it was also important to evaluate the approach to gain user opinion on the module. Evaluations were undertaken by participants throughout the completion of the module. Areas such as the layout and content of the module were addressed in addition to individual thoughts on e-learning for revision and teaching purposes.

The raw data uploaded from the grade book for each evaluation can be viewed in the appendices (Appendix 11). This qualitative approach will be analysed through the use of charts created in Microsoft® Excel.

An evaluation was undertaken at each stage of the course to gather overall opinions on the module, its teaching content and individual thoughts on strengths and weaknesses of the module. Questions included a multiple choice format where participants rated something high or low and yes/no questions were included for participants to state whether they used or liked certain features. In addition to these, comment boxes were made available to gain individual opinions on what participants thought of the course, what they would change and what they would add to the course.

In most cases the analysis of the evaluation data has been undertaken on all participants as one group due to results showing high trends. Individual levels have been analysed where appropriate, however it was found (and can be seen from the raw data) that individual levels have generally shown similar trends with regards to the majority of questions.

4.2.1: Thoughts on timing, instruction and navigation of "Developmental Osteology"

Navigation with constructive guidelines and expectations are essential qualities for distance learning. Participants were provided with instructions on how to navigate the course in addition to learning objectives to allow them to understand what they should learn from the course.

Figure 36 represents the percentage of participants answering yes or no to questions regarding their thoughts on their expectations of the module and whether they understood the instructions given to them. They were also asked whether they were given enough time to complete each test as there was a time limit set.

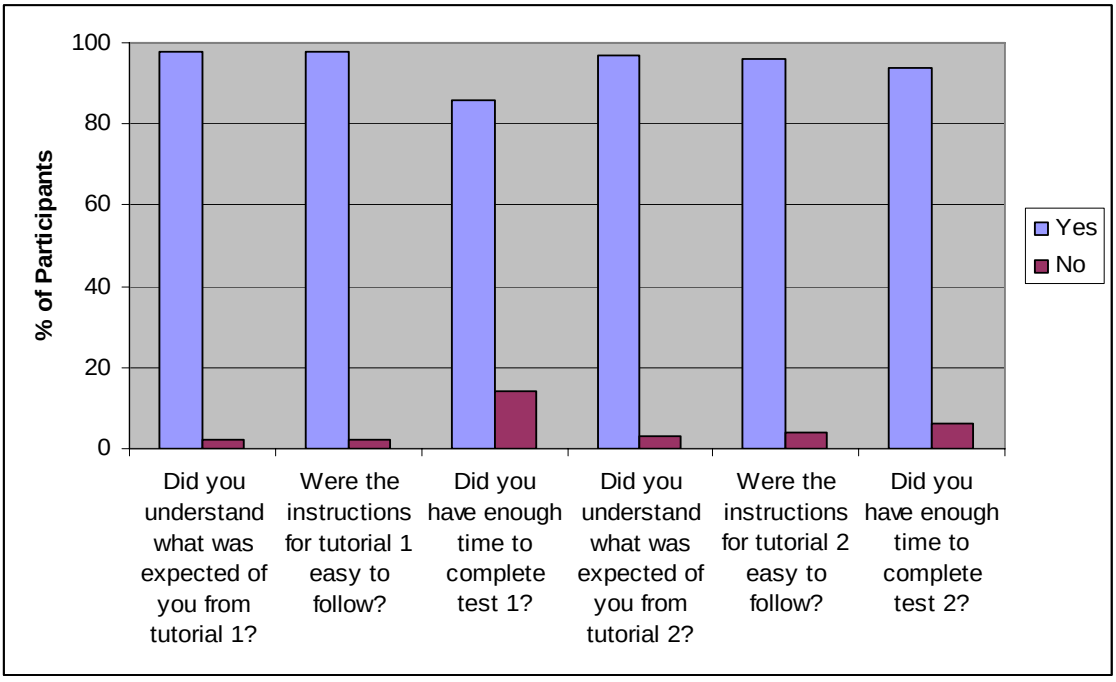

Figure 36: Questions on timing and instructions.

High percentages were recorded for participants understanding of the expectations and instructions for tutorial 1 and 2. This suggests navigation, layout and expectations of the course were clear. The majority of participants recorded that they had enough time to complete the tests and there were few individual opinions regarding increasing the time. This suggests that if the course continued in the future, the time set for participants to complete the tests could remain.

Participants were asked for their comments at the end of each evaluation. Individual opinion collected on the navigation of the module was relatively positive, as participants stated " tutorials were easy to follow" and "well structured" however some negative points such as "navigation... is more awkward than it needs to be" were also made. As participants had to complete the module in a specific order the instructions of where to go next were often complicated. If the instructions were not understood, participants were "lost" within the module as they did not know where to go next.

The majority of e-mails received from the participants throughout the completion of the course were due to navigation issues. Generally, participants were directed back to the instructions within the module as they may not have read / understood them initially. These were all overcome as all the participants with any queries completed the course. This suggests that although instructions are put in place, it cannot be guaranteed that participants would read / understand them.

Overall this area was rated highly. Alterations would be made in the future should the project continue. A smoother navigation with more instructive guidelines would help prevent users getting "lost."

Participants were asked for their opinion on what they would change and add to the course. A few suggestions for navigation were made, but these generally involved more links to the next step.

4.2.2: Thoughts on the teaching material within "Developmental Osteology"

Throughout the evaluation stages participants were asked a number of questions relating to the teaching material within the module. Individual opinions from comments boxes were also received.

- **Text**

A balance of effective images and activities with suitable text was pursued for this module. To avoid limited information through sparse text and to prevent overwhelming participants with too much text a, "happy medium" was created. Participants were asked their thoughts on the amount of text within the module. Figure 37 shows participant answers to this question with a high majority stating there was just enough text.

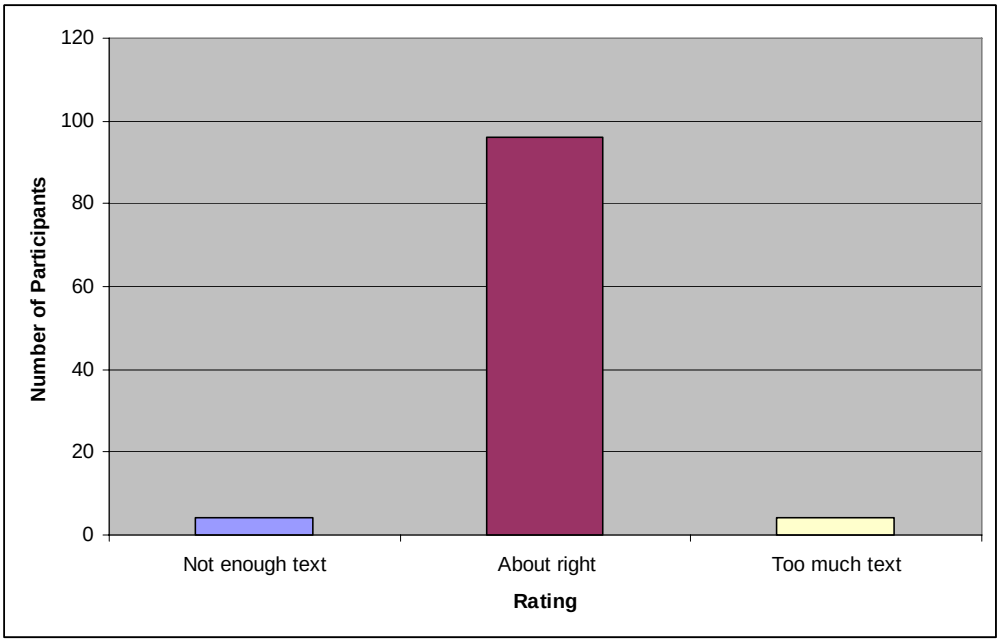

Figure 37: Participants rating of the text within the module.

Individual opinions on the text have also been documented from the "any comments" questions within the module. For example; there was "no text overload," "just enough text on screen.. not overwhelming to the reader." However, "I would have to look at the textbook for more detail," "add more background text" and "more text in some areas (as some parts were) explained vaguely" were some comments made by participants which suggested that participants wanted more information.

Colour coding the text with images was also reported to be successful as it helped with understanding. Figure 38 shows participant opinion on the colour coding, as this has been rated highly this method would be used if the module was to continue in the future.

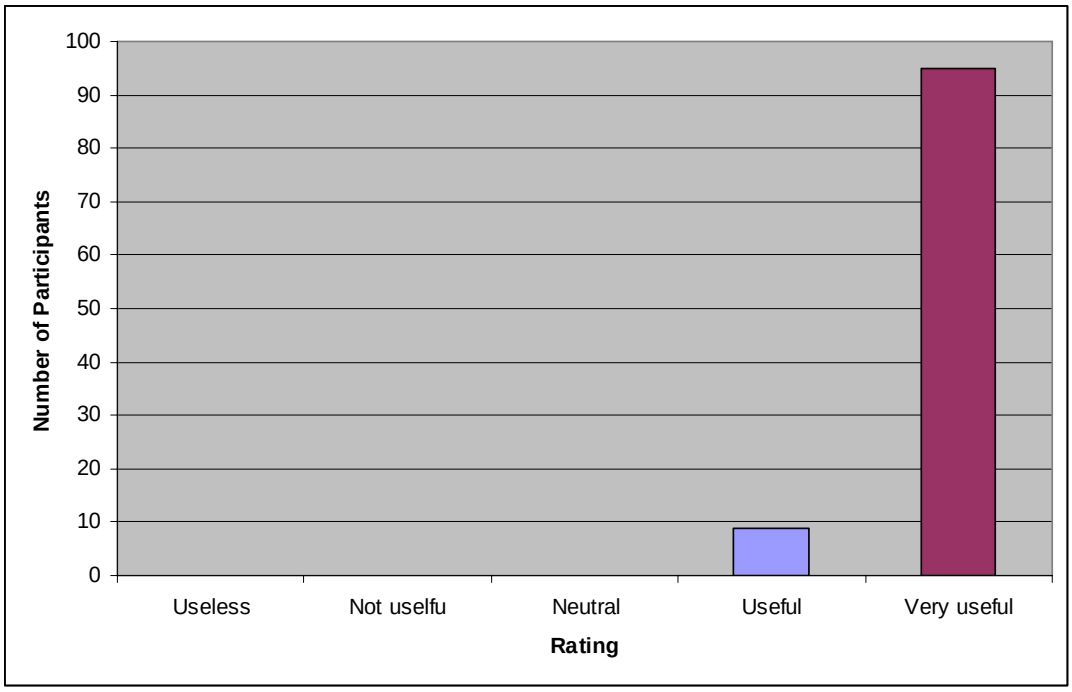

Figure 38: Participants rating of the colour coding text within the module.

As participants had a mixture of backgrounds it was inevitable that participants with previous knowledge would be more confident with the academic material as they were familiar with it. However, participants with little knowledge may have been overwhelmed by the amount of information required for understanding. Not only did they

have to learn the morphology and development of the innominate bone, but in order to understand these, a level of basic anatomy was required. This area was not tested within the module and required participants to access an external link to the anatomical terms page if they thought they required the information. A small number of individuals reported some concerns in the "any comments" question in the evaluations for example; "It's an awful lot to take in... especially if one is new to the terminology" one suggestion from a student was to "include tutorials for general anatomy".

If this module was to be used in the future and extended into other regions of the skeleton, an introduction into anatomy would form the first tutorial. As this was a test module, looking at teaching the development of a particular region of the skeleton, teaching anatomical terminology was not the priority, however brief descriptions were included in the anatomical terminology and glossary pages.

- **Glossary and Anatomical Terminology pages**

In the tutorial 1, participants were directed to the anatomy terms page at the start; therefore as it was part of the tutorial participants would have clicked on it. However, this feature was not tracked; therefore the exact number of times it was used cannot be determined. At no stage was the anatomical terms page a compulsory link, however it was made available on the initial page where participants could access it if required. This may explain the smaller number of people accessing the anatomical terms in status 2 and the glossary as participants were not directed to it (Figure 39).

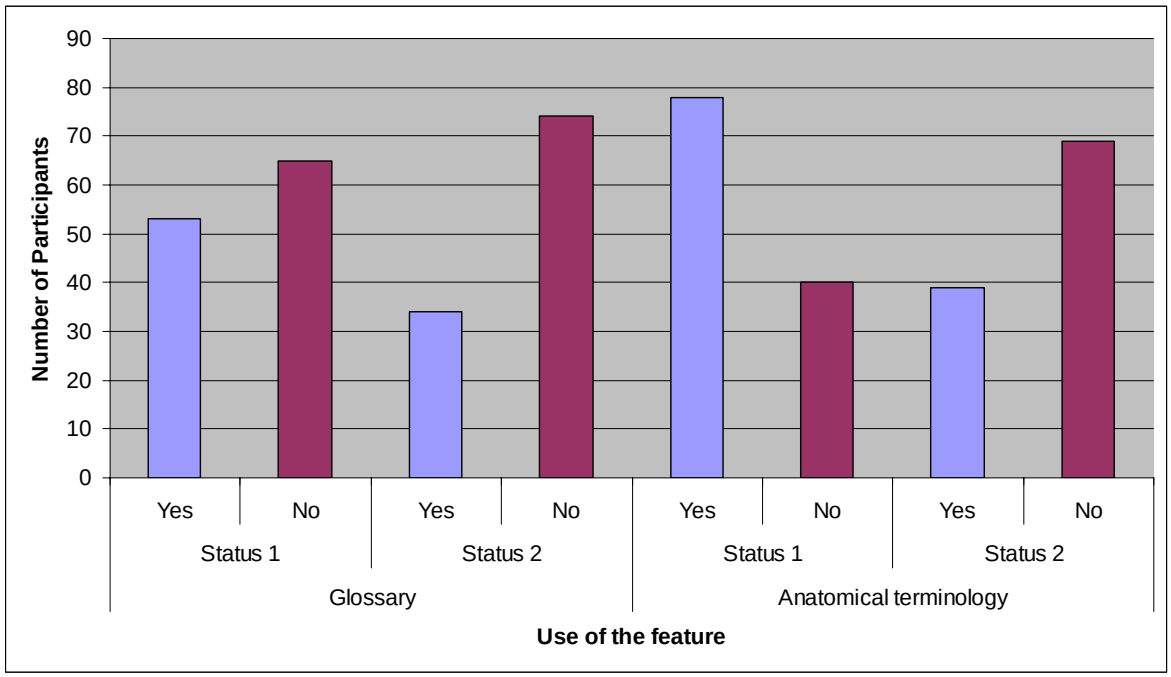

Figure 39: Participations use of glossary and anatomical terms pages.

Further analysis into individual levels use of these features has been undertaken in table 95. For the use of the glossary, level 3 and 4 have demonstrated that a larger majority have accessed the feature. Levels 1, 2 and 5 show more participants have used the feature than have not, but a high majority has not been observed. However, these levels (1, 2 and 5) have shown the largest use of the anatomical terms page. This is understandable as they have little background in basic anatomy whereas level 3 and 4 have.

	Use of Glossary		**Use of Anatomy Terms**	
LEVEL	**Yes**	**No**	**Yes**	**No**
1	18	14	24	8
2	10	7	13	4
3	8	18	14	12
4	7	14	10	11
5	10	12	17	5
TOTAL	**102**	**105**	**102**	**105**

Table 95: Levels 1-5 use of the glossary and anatomical terminology pages.

These tools were available to give definitions to unknown words, therefore participants may not require the use of them if they already had the knowledge.

As seen in Figure 40 the majority of participants have given positive feedback on these features with the majority reporting them useful or very useful. Although accessing the glossary and anatomical terms pages was not fully utilised (Figure 39), participants rated them highly in terms of usefulness, this may be due to users not requiring them during completion of the course, but found them a useful addition to the module as a potential support mechanism.

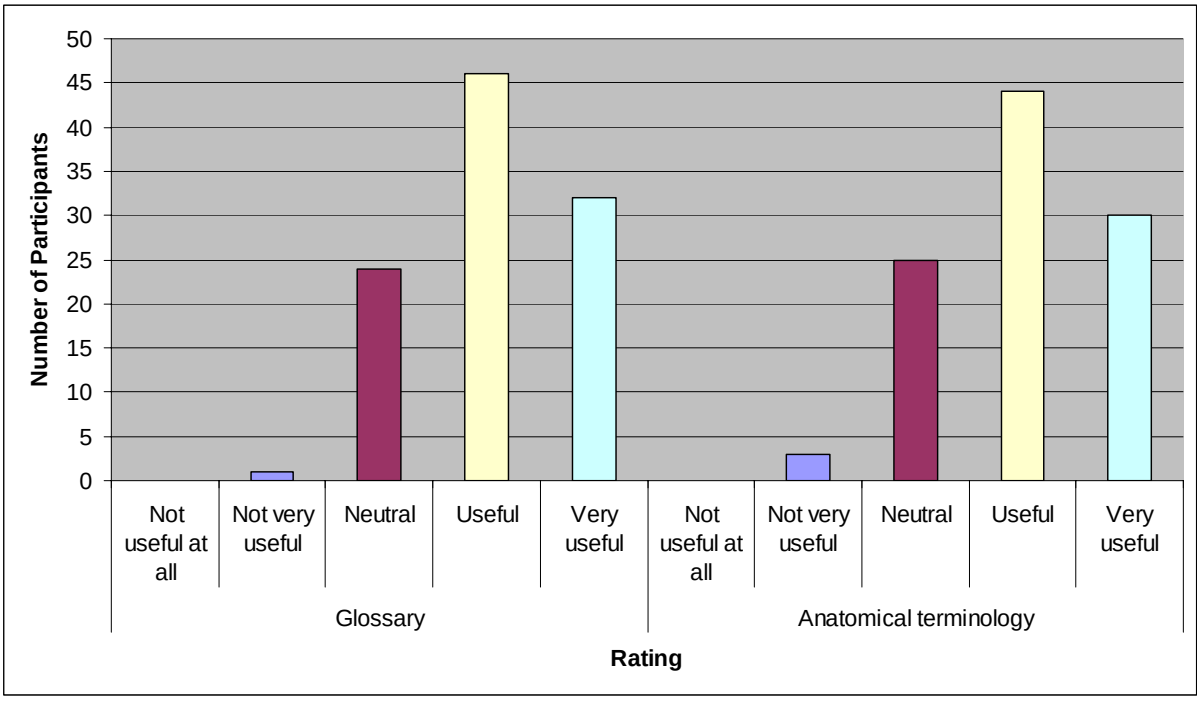

Figure 40: Participants rating of the usefulness of the glossary and anatomical terminology features.

- **Interactivity**

As discussed previously, interactivity of a course is essential for engaging the learner and aids in their understanding. The opinion of the level of interactivity of the module was asked in the final evaluation where participants rated on a scale from "very good" to "very poor". As seen from Figure 41 the overall rating of interactivity

was high for all participants together. As there is a high positive majority, individual levels have also shown this trend.

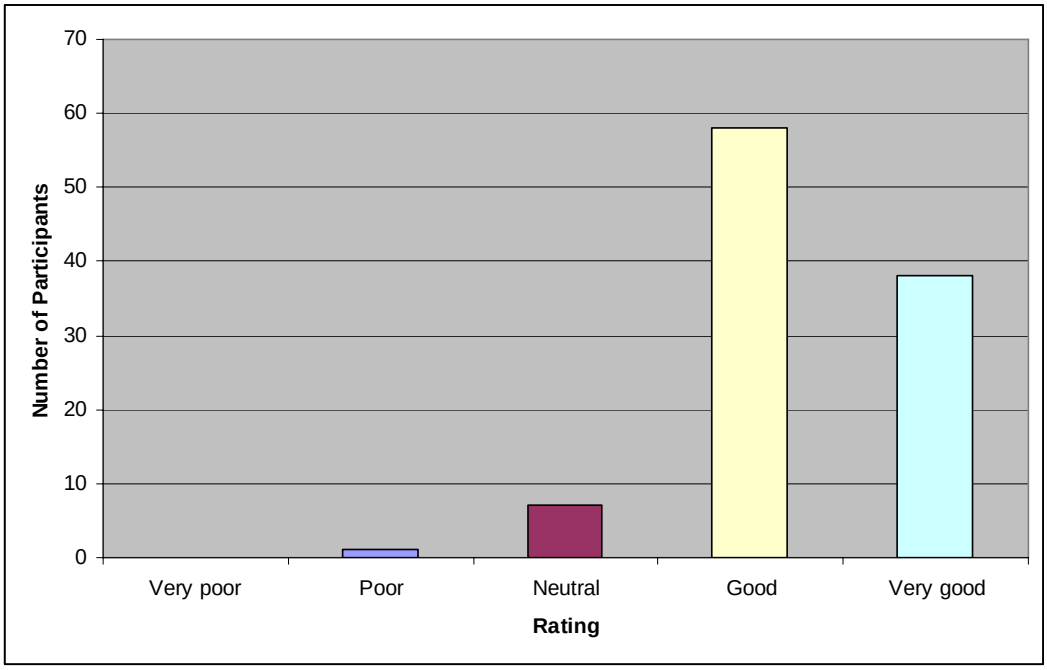

Figure 41: Participants rating of the interactivity of the module.

Participants were asked to state if they would change or add anything to the module, a number of evaluations commented on increasing the interactivity of the course. Although the module was rated as highly interactive, a number of participants would like to see more. Comments such as; "Make it as interactive as possible" "more interactive parts would be great" were received.

As this module was set up as a test to assess its suitability for teaching, a number of features were subsequently tested. Elements such as the glossary (previously discussed) as well as drag and drop images, which received positive feedback from the evaluations where participants said they would like to see more as they are a useful revision tool.

In order to make the module as interactive as possible, in the future the 3D elements of the course would be improved. As discussed in Chapter 3 a proof of concept was created to test the suitability of

teaching from this method before developing the course further. As participants were evaluating the proof of concept one question to be addressed was;

"Can we learn from 3D digital images of the Scheuer Collection in the same way as learning from the real thing?"

Four specimens were used to create digital 3D models which were converted into animations uploaded and used within the module. These specimens were chosen as they conveyed the development of the innominate at different stages of development. As discussed in Chapter 3 a single proof of concept was created as the time for conversion into a 3D interactive animation proved to be extremely time consuming and relied on another department for its contribution.

As a result, rotating animations were completed for 3 of the specimens and an interactive labelled 3D horizontally rotating animation was created as the proof of concept. These were all addressed within the evaluations to gain participant opinion.

Participants were asked to compare 2D images to the 3D aspects of the course. Although there is a high rate of participants rating the 3D activities as more useful or very useful compared to 2D images (Figure 42), there was nothing to suggest the 2D images were not useful or were unhelpful. A high number of people (88 out of 102) also reported that more 3D activities would help them to better understand the development of the innominate.

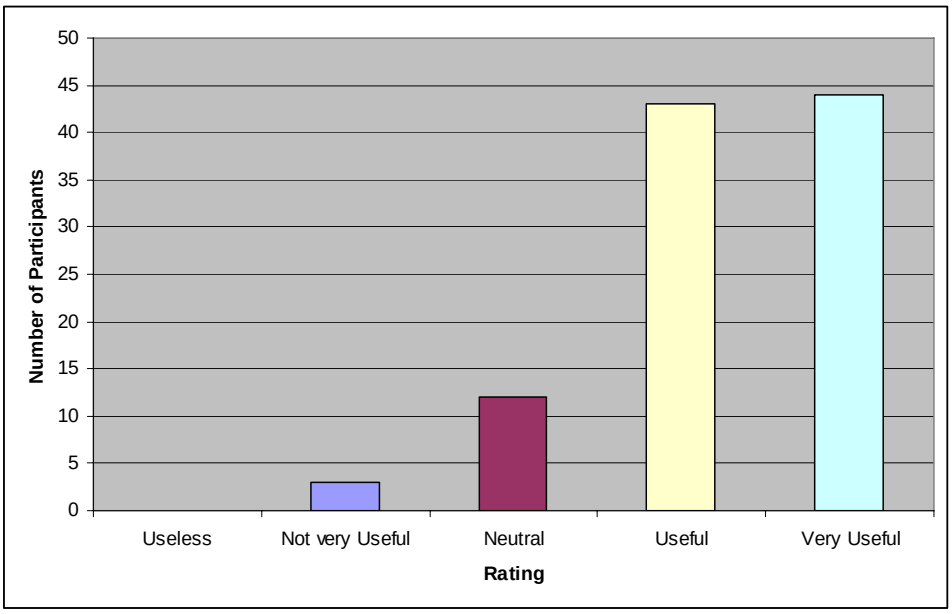

Figure 42: Participants rating of the usefulness of the 3D activities compared to 2D images used within the module.

Figure 43 shows the number of participants rating the proof of concept for its helpfulness in describing the palpable parts of the human bony pelvis (Appendix 11). Results indicate a high number of participants rating the 3D activity helpful or very helpful (95 out of 118). Participants were also asked (yes/no) if the 3D activities would be useful for other parts of the tutorial in which only one participant out of 118 stated no. As this was a preliminary study, it was essential to test a number of different methods of teaching to gain user opinion which would influence and improve future developments.

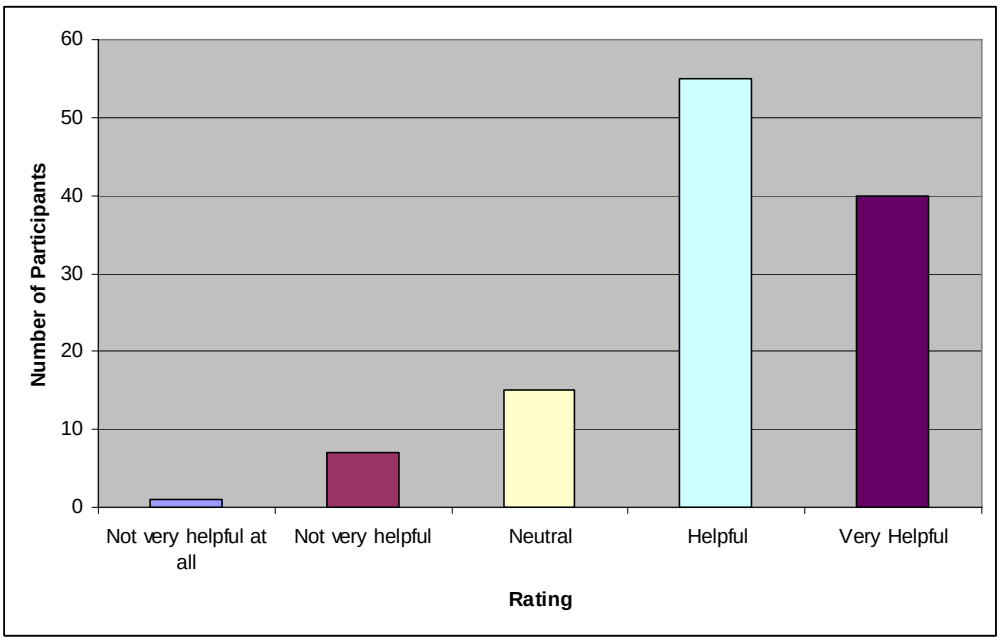

Figure 43: Participants rating of the proof of concept.

Participants with experience of learning from the remains of Scheuer Collection were asked to compare the 3D rotations to the real thing. In total, out of 43 participants with experience of the Scheuer Collection the majority (24) expressed that the 3D digital models were the same as the real thing (Appendix 11). Understandably there were few (3) participants who reported the models to be better than the real thing. However, it was the intention to create models which would represent the real specimen effectively, not to create something better than the real thing. Converting elements of the Scheuer collection into 3D digital format has been successful, and these results demonstrate its suitability as a digital learning tool.

Individual thoughts generated from the "any comments and additions / changes" questions within the evaluations were generally full of suggestions / thoughts on the 3D aspects of the course.

From the "any comments" questions, people explained the problems with loading times as well as not being able to see some of the 3D features. All the 3D model files were kept to a minimum size;

however using slower running computers would cause short delays. The instructions stated that these animations may take time to load as there was no way of overcoming this practicality. The instructions also stated to use Internet Explorer as the images would not load onto Mozilla Firefox. However, a number of participants stated in the evaluation that they could not see the images and that they used Mozilla, therefore suggesting instructions were not always read fully.

From the "any changes" and "any additions" questions in the final evaluation the majority of responses focussed on the 3D animations. Participants stated that more features and labelling (like the proof of concept) should be added in addition to full 360 degree rotation on a number of axes. Should the module be extended into the rest of the skeleton, these changes would be made to the innominate animations as it would give more freedom and heighten understanding of a complex 3 dimensional concept.

- **Confidence**

Although the module has been found to teach the participants (through the assessment data), it has also increased their confidence on the subject. Figure 44 represents the percentage of participants answering yes or no questions regarding participants' confidence after completing the tutorials and if they thought their knowledge improved following the tutorials. A high percentage of participants stated they were more confident taking the tests after completing the tutorials. Participants also reported a high rate of understanding the morphology and development of the innominate bone following completion of tutorials 1 and 2, suggesting participants felt they improved their knowledge following completion of the online activities. As there is a high positive majority, individual levels have also shown this trend.

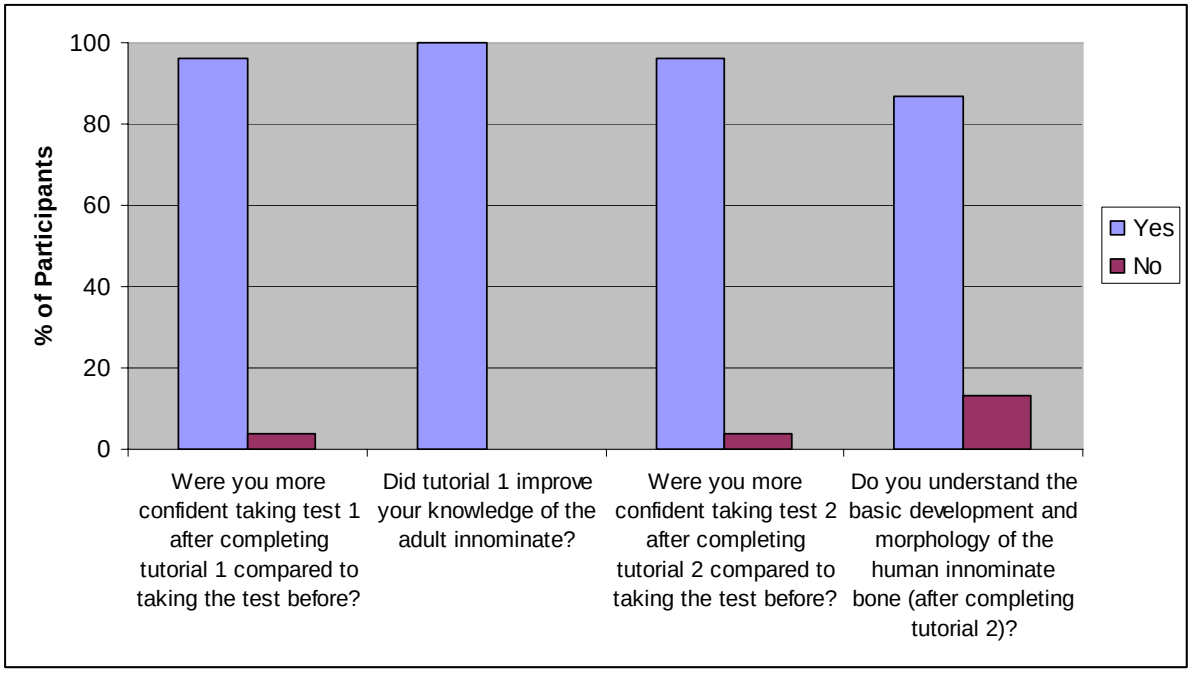

Figure 44: Questions on confidence and knowledge.

4.2.3: Thoughts on "Developmental Osteology" and its role as a revision / teaching tool

Figure 45 represents the percentage of participants rating the idea of online learning at the initial stages of the module with regards how useful it is as a tool for revision. A high number of positive reviews were received initially, however this percentage increased by the final evaluation, where participants were asked to rate the entire module as a tool for revision (Figure 45). As there is a high positive majority, individual levels have also shown this trend.

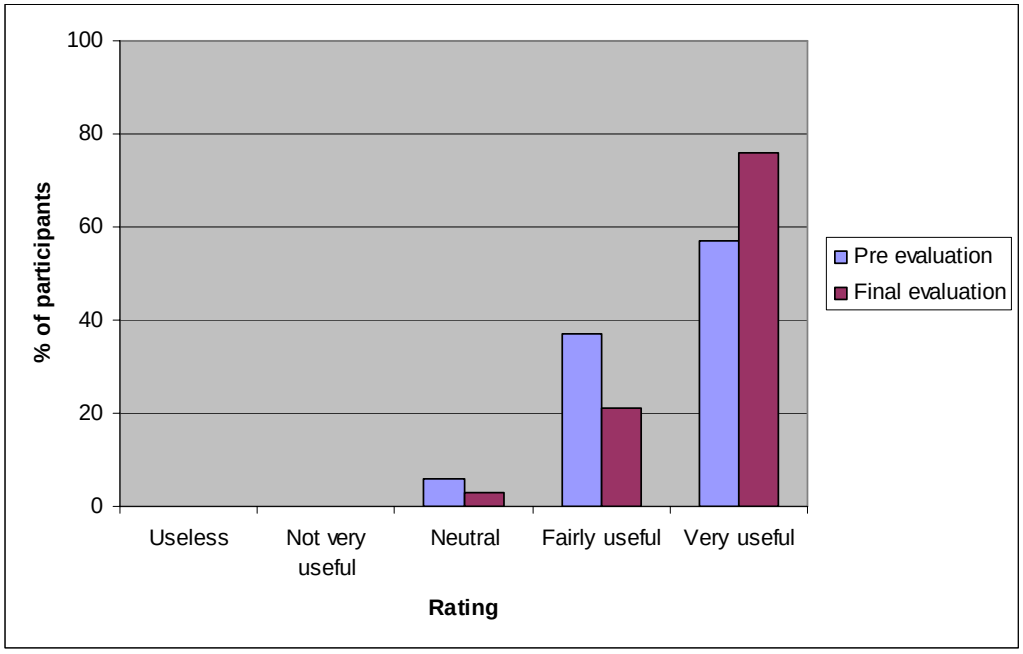

Figure 45: Participants rating of the module as a method of revision.

Participants were also asked to rate the module as a method of teaching in the final evaluation. Positive feedback was received, which can be observed in Figure 46, however this did not determine if participants would prefer online teaching to traditional face-to-face teaching. As there is a high positive majority, individual levels have also shown this trend.

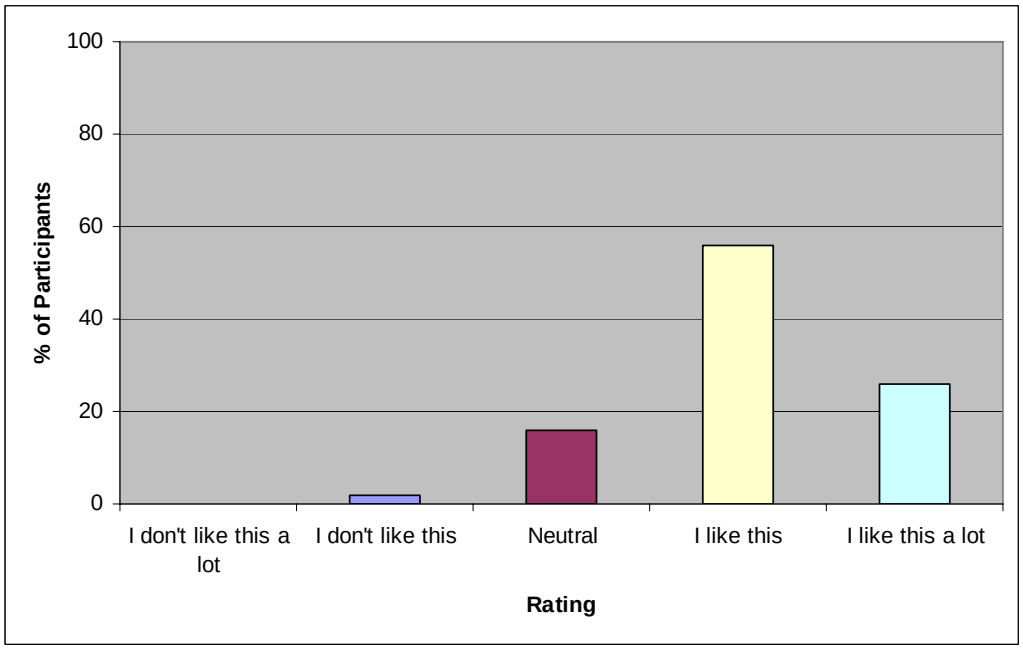

Figure 46: Participants rating of the module as a method of teaching.

Participants were asked to compare teaching online to teaching face-to-face which showed a high neutral status (Figure 47). The high neutral status may be due to participant's limited experience with online learning. Individual levels all show a high neutral status, demonstrating that participants have not shown a high positive or negative opinion. From the raw data, it can be seen that no individual level has demonstrated a trend other than high neutral.

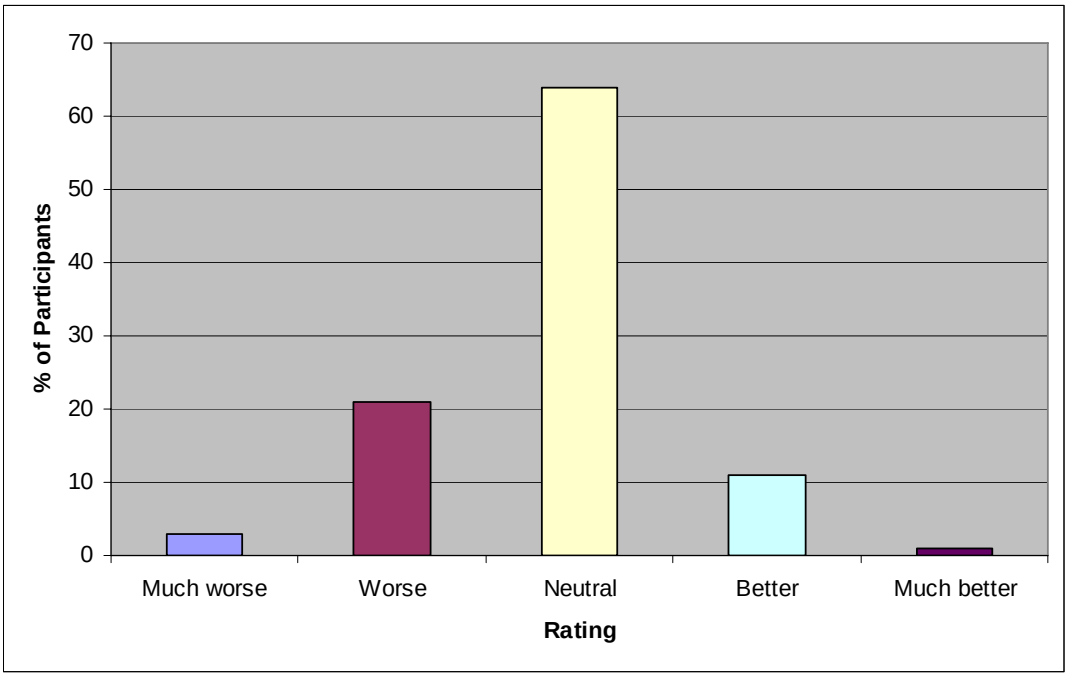

Figure 47: Participants rating of the online learning compared to face-to-face learning.

Individual opinions gained from the evaluations showed the opinion that it is a "fantastic" tool for learning which should be used as a "study bonus" or used at the same time as "studying the real thing in the lab" but should "not be used as a primary teaching tool" or replace the actual lectures.

Overall the evaluations demonstrated a positive reaction to "Developmental Osteology" for its layout, expectations of the course and participants thoughts to their improvement of knowledge. The module can be best described as an addition to teaching, which can be used as a revision tool or teaching aid, however, should not replace the traditional course.

Chapter 5.

Discussion

Supplementing or supplanting traditional methods of teaching with online alternatives is widely being considered in the area of learning and teaching. Currently, there are a limited number of courses on forensic anthropology available online, and there are no known online courses on the development of the skeleton.

It was the intention that online supplements would be considered for teaching the development of the skeleton at CAHID for this project, not only to act as an educational resource for students, but also to assess if the digital models of the Scheuer Collection are suitable as a substitute / aid to teaching.

This chapter aims to conclude the suitability of the module from the discussed results from the previous Chapter (4), and will also address any changes required for its improvement. The participants will be discussed with regard to their willingness and communication during their participation of the project. Future plans for the test module and its expansion into other areas will also be discussed.

The suitability of "Developmental Osteology"

Before introducing a module or activities online, they should be tested on colleagues to gain opinion of the conversion (O'Leary and Ramsden, 2002). Therefore, this preliminary study aimed to create a test module on the development of the innominate in order to test the suitability for teaching the development of this region. In addition to colleagues (staff), undergraduate and postgraduate students were enrolled on the module to test its suitability as a learning tool.

Overall, Chapter 4 demonstrates that participants improved their score following completion of tutorials 1 and 2. Statistical analyses confirmed there was a positive interaction between scores obtained before accessing the online material and scores after completing the material. Although participants from lower levels without experience of anatomy did not improve to a pass rate of 60%, they did improve significantly. There was a significant volume of information to absorb by these participants; however results still increased which indicates they did learn from the teaching material. Increases were also seen for higher levels which shows that although they had some previous experience, the online tutorials seemed to improve their knowledge or at the very least re-establish previously learned information.

Initially, it was the intention of this project, for the test module to be accessed in conjunction with the level 3 traditional face-to-face module "Juvenile Osteology." However, due to timing issues (described in Chapter 4) this was not the case, resulting in the a number of participants completing status 1, test 1 11 months before completing tutorial 1 and test 1 (status 2). In one way this was advantageous as it would have been difficult to test from where participants actually gained their knowledge.

However, the major disadvantage created by this was that the current level 3 completed a course on "Introduction to Anatomy" between status 1 and completion of tutorial 1. Although results have increased between status 1 and 2, it was not possible to test with reliability from where participants gained their knowledge. The pre-test should have been taken close to participants having access to the tutorial to avoid this problem, however the time taken for the completion of the module was not predicted and took considerably longer than expected.

Level 4 completed "Human osteology" and "Gross Anatomy" (in their level 3) which resulted in possible effects on scores between status 1 and 2 for tutorial 1. However, this enabled these participants to compare the digital images of the Scheuer Collection with the real thing which was important.

No other participants were affected by this as they did not complete any modules on the adult innominate between status 1 and 2. Tutorial 2 and the tests taken in status 1 and 2 were also not affected in this case as the gap between status 1 and 2 was outwith the academic calendar, and there were no other modules running at this time.

In the future should a module require to be tested in this way, it is suggested that participants take the pre test (status 1) closer to having access to the teaching material, to ensure little external influences.

In addition to the success of the module seen by the increase in scores, participants also gained confidence as the number of "don't knows" answered decreased overall. However, on occasion the "don't knows" decreased whilst the wrong answers increased, suggesting an increase in confidence that was not matched by an increase in knowledge.

The evaluations also demonstrated participants' increase in confidence which was advantageous for the suitability of the module. Evaluations were also used to assess the layout of the module. Results overall suggest that participants found the module to be informative, clear and well structured with good interactivity. Participants individual comments however showed that some would have liked more interactive activities.

Navigation was also discovered to be a slight problem with some participants as they found it difficult to move between stages within the module. To ensure participants were accessing each part of each tutorial, each was made available following completion of the previous one. This resulted in the module not being completely smooth as participants were commenting on being "lost" and required further direction. Although instructions were given at each stage to help with navigation, it cannot be guaranteed that participants will read them. Following initial communications regarding users being "lost" they were directed back to the instructions which generally solved the problem. In the future, the layout of the module would remain very similar with more emphasis on the instructions and extra links to each section.

Overall, results have demonstrated that "Developmental Osteology" was successful, however would require minor changes should the project continue.

The suitability for teaching with elements of the Scheuer Collection

The 3D digital animations created were evaluated by participants throughout completion of the module. These were overall rated highly, however individual comments on the 3D rotations (not the proof of concept) demonstrated that participants wanted more labels for improved understanding. As this was desired previously, but was not possible due to timing and training issues, the comments from the participants demonstrated that the idea of 3D interactive animations was found to be positive, however they require the highlights and labels as seen on the proof of concept for better understanding.

In addition to labels and highlights, a zoom and rotation feature would be available to give users more freedom with the digital models. Quizzes using the 3D models would also help participants learn the features on the model, with the hope that they could identify them should they be presented with a real specimen. It is the author's opinion that this area of the module was hindered due to the author's lack of freedom with this aspect. It was initially thought that the ideas for the 3D animations (discussed above) would have been available for the test module, however due to timing, training and software issues, this was not possible.

However, participants demonstrated that they liked this way of teaching by explaining that they would like more of these activities. Therefore further training would give the author the freedom to improve the 3D animations to their full potential.

Participation

The majority of participants who were contacted with regards to taking part in the project did so without hesitation. However, a number of participants required persuasion from their head of department and e-mail reminders for the tasks they required to do. Out of 147 people enrolled on the course, 102 completed the entire module (102 completing tutorial 1 and 105 people completing tutorial 2). Out of the 45 participants who did not complete the entire module, the majority had left the University of Dundee and did not have access to the VLE.

It is the author's opinion that participants were not pressured to partake in the project, but that their participation was proactively sought. The module would aid level 1-3 students with future modules within their degree and would serve as a revision tool for level 4 and

5, therefore it was portrayed as being in their own best interests to take part.

Communication was successful within the module as the majority responded well to e-mails. As the announcements page was not tracked, it is not possible to determine if participants were accessing it. The discussion board was used to raise issues regarding feedback on tests and report any problems encountered. Raising an issue on the discussion board showed that participants were utilising the communication facilities on the module online to voice any personal concerns or queries.

All comments posted on the discussion board were named, therefore participants did not make the choice of appearing anonymous. Participants also commented on the discussion board positively, which was useful to evaluate the module at different stages of the research. Although the total number of comments was quite low (19), the discussion board was a successful alternative communication tool to e-mails. E-mailing was the primary method of communication between participants and the instructor where over 400 emails were sent over the year.

Overall, participants were extremely willing to partake in the completion of the online module. Their enthusiasm has been documented in e-mails received and suggestions made for the future, and it is the hope that their interest in the subject was heightened by having the opportunity to be involved in an ongoing project.

Next steps

Addressing the development of the innominate was the first step taken to discover the suitability of the academic material for teaching purposes. The problems documented above can be overcome if the test module was to be utilised in the future. The success of "Developmental Osteology" has created an opportunity to expand into addressing the remainder of the skeleton and its development.

Although participants of the project with experience of the Scheuer Collection were asked to compare the 3D animations to the real specimens, it may be of interest to return to the participants with no experience and test them on the real thing. This may heighten the research should it prove to be successful.

The problems faced by this project would also be addressed in the future to ensure a more effective teaching tool. The method of scanning elements of the Scheuer Collection would be reconsidered as it proved to be extremely time consuming and problematic. A possible solution to this would be CT scans of the remains. These images would also have to be tested for suitability of teaching as the surface texture would be lost, however greater detail would be captured.

Creating animations from these digital 3D models requires software for which the author had no experience and training would have taken a considerable time. As these animations relied on another department for their expertise, self training would be considered in order for the course to be priority as this was not the case for department contacted for the project.

Once the current module was improved with greater interactivity, this method could be considered for other regions of the skeleton. The module would be directed to level 3 students who would have access to the module for revision purposes during the completion of their face-to-face module in "Human Osteology."

Should the module on the entire skeleton be considered for external use, as a method of teaching without any face-to-face alternative, a number of areas would require to be addressed. For example, in addition to the current anatomical terms page (which is useful for revision) a module on basic anatomy would be included. As level 3 students will have this knowledge they would not require an entire section on basic anatomy. However should the module be used for distance learning, users would require to complete a section on basic anatomy to ensure they are ready to complete a course on the development of the skeleton.

If the creation of an entire module on the development of the skeleton is developed and proves to be successful, the possibilities of expansion are numerous. In addition to addressing subjects within forensic anthropology such as aging, sexing and pathology, other areas of forensic science could form part of an online course in forensic science.

Templates would be created for modules and expertise worldwide would be contacted for their input. This would provide extensive collaborative opportunities in a similar way to IVIMEDs. An international virtual degree in forensic science (IVIFOR) could realistically be pursued following the tentative success of "Developmental Osteology."

Soon after completion of the module, tutorial 1 was utilised for level 1 medical students at the University of Dundee. This e-learning activity has been embedded into their VLE system as a revision tool and has also given the teaching staff the drive to create their own online learning tools for their students (Pers comm. Mitchell, 2008). Therefore, not only has "Developmental Osteology" been a useful tool in itself, but it has also given staff involved in the project an insight into what a VLE system has to offer.

Conclusion

Online e-learning activities are currently being adopted by a number of academic institutions to supplement and in some cases supplant traditional face-to-face learning. Following research into this type of learning in the subject of forensic anthropology and more specifically, the development of the skeleton, it was found that there were limited facilities online for this particular training. As the University of Dundee has the expertise in the development of the skeleton and houses the unique Scheuer Collection, the development of an online module teaching the development of the skeleton was best pursued here.

Before implementing teaching facilities online, they require to be tested. 102 participants completed the test module; these participants were students and staff of CAHID. Results found the test module to be a success as participant scores increased and evaluations were largely positive. A number of areas were highlighted to have some weaknesses; however these were minimal and would be addressed should the module continue in the future.

The major flaw in the results were that level 3's results for tutorial 1 could not be used for determining the effects of the online module as

timing issues caused this group to complete a course in basic anatomy which would have contributed to some extent in their increase in score. Other results indicate that it may have been beneficial for lower level participants to complete a full tutorial on basic anatomy before completing the course as the language was a major obstacle.

Overall, the evaluations rated the module extremely beneficial to learning. Gaining participant views was important as it gave feedback on a number of aspects of the course. Evaluations also provided a number of ideas to improve the module.

Due to the success of the test module from an assessment and evaluation perspective the module could be developed into other regions of the skeleton and beyond. Although the module has not been found to be an alternative to traditional teaching, its use as a study guide or revision tool was highly encouraging.

In the possible event of the Scheuer Collection being dismantled, the alternative digital images created for this project were ultimately found to be a useful teaching tool. With appropriate adjustments to the digital models making them as interactive as possible with rotating, zoom and labelling activities, these could replace handling the remains should this be required.

The success of "Developmental Osteology" has created opportunities to expand into the rest of the skeleton and other areas of forensic anthropology and ultimately perhaps even challenge the current profile of teaching forensic science.

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The International Virtual Medical School

International Virtual Medical School (IVIMEDS) Survey

We would like to ask you to help us with the further development of the IVIMEDS Cardiovascular learning resources. It is only through your open and honest feedback that we can continue to improve.

Your completed questionnaire and the information that you give us will be held in the strictest confidence in the IVIMEDS office. A report will be prepared but no student will be identified by name. We will send a copy of the report to you. As an acknowledgement of your help we will enter the names of all who return the questionnaire into a draw. The winner will receive book tokens to the value of £80.

Name (please print) _____ Group _____

First please tell us how you used the resources

1. Please estimate how much time overall you spent with the resources.

None ☐ 1-3 hours ☐ 4-6 hours ☐ 7-10 hours ☐ >10 hours ☐

2. Estimate the percentage of the total time you spent with the material at different locations.

In the computer suite at Ninewells _____ %
Elsewhere at Ninewells _____ %
At other sites (please specify) _____
100%

3. Estimate the % of the time you spent with the material.

Individually on your own _____ %
Working along with a colleague _____ %
100%

The guided learning modules

4. Which of the following best describes how you used the modules.

☐ I systematically worked through the programmes
☐ I systematically worked through the modules but before doing so I looked at the content list on the left side of the screen
☐ I browsed the programme and explored pages that I thought might be on interest
☐ All of the above

Comments

5. Which feature of the guided learning modules did you make use of? Please also rate whether you recommend that the feature should continue to be included with the module.

	Useful to me					Recommended for inclusion in programme				
	Definitely not	Probably not	Uncertain	Probably yes	Definitely yes	Definitely not	Probably not	Uncertain	Probably yes	Definitely yes
Self assessment questions										
Audio commentary that accompanies the text introducing each frame										
Links to internet sites										
References to pages in text books										
Links to electronic text books available on line with the IVIMEDS resources										
The discussion forum										
The animation sequences										
The video demonstrations e.g. dissection of heart										
The video clips of experts expressing a view on a topic										

6. Please rate your level of satisfaction with the CVS guided learning modules.

	Very bad	Bad	Neutral	Good	Very good
Ease of navigation through the programme					
Screen layout					

	Far too much	Little too much	Just right	Too little	Far too little
Quantity of information in CVS guided learning modules					

	Much too simple	Too simple	Just right	Too advanced	Much too advanced
Level of content in CVS guides learning modules					

7. I think that the IVIMEDS learning materials

	Definitely not	Probably not	Uncertain	Probably yes	Definitely yes
Were relevant to my learning					
Helped me to learn on my own					
Helped me to understand the normal structure and function of the CVS					
Helped me to understand the pathophysiology of the CVS					
Helped me to understand the clinical aspects of the CVS					
Supported my learning from the lectures					
Helped me learn things I would not have learned in lectures alone					
Helped me learn things I would not have accessed from other sources e.g. books, internet					
Would be useful when revising the CVS					

The virtual patients

In addition to the guided learning modules you were given access to patients from the IVIMEDS bank of virtual patients.

8. Did you access the virtual patients?

Not at all ☐ One patient ☐ More than one patient ☐

Comments

9. Was this a useful experience?

Definitely not ☐ Probably not ☐ Uncertain ☐ Probably yes ☐ Definitely yes ☐

Comments

10. Was the navigation satisfactory?

Definitely not ☐ Probably not ☐ Uncertain ☐ Probably yes ☐ Definitely yes ☐

Comments

11. How did the virtual patients contribute to your learning?

More generally...

12. How would you rate overall the IVIMEDS resources in terms of usefulness as a learning resource?

Definitely of no value ☐ Probably of no value ☐ Uncertain ☐
Probably of value ☐ Definitely of value ☐

13. How would you rate overall the use of the IVIMEDS resources in terms of enjoyment?

Definitely of no value ☐ Probably of no value ☐ Uncertain ☐
Probably of value ☐ Definitely of value ☐

14. Would you recommend other students to use the IVIMEDS resources?

Definitely not ☐ Probably not ☐ Uncertain ☐ Probably yes ☐ Definitely yes ☐

15. Are you comfortable using computers to learn?

Definitely not ☐ Probably not ☐ Uncertain ☐ Probably yes ☐ Definitely yes ☐

16. Was working with other students useful?

Definitely not ☐ Probably not ☐ Uncertain ☐ Probably yes ☐ Definitely yes ☐

17. Were there any aspects or elements of the learning experience that supported your learning most?

18. Were there any aspects or elements of the learning experience that supported your learning least?

19. What do you see as the advantages of using the IVIMEDS resources?

20. What problems or difficulties did you encounter? What would you change?

21. Any other comments?

Thank you for your help.
Please return this questionnaire to the Curriculum Office.

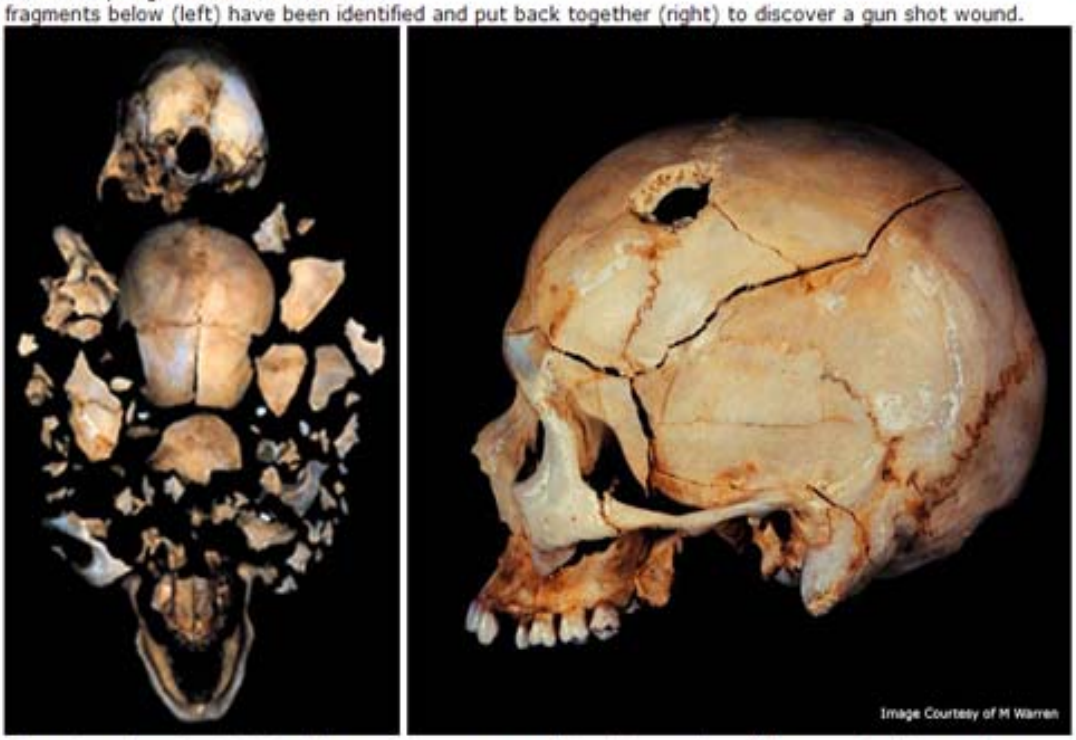
Your name will be entered into a prize draw and you will be sent a copy of the report.

Introduction

Background

I am currently a master by research student in the centre for anatomy and human identification here at the University of Dundee. I graduated in forensic anthropology in the summer and I am continuing my studies here by creating an online interactive learning package on the development of the human skeleton.

As many of you have already discovered, and more are yet to discover, a huge part of forensic anthropology is knowing the human skeleton from head to toe, from fetal development to old age and from entire specimens to a thumb sized fragment. This information will help the forensic anthropologist in cases such as this;
The fragments below (left) have been identified and put back together (right) to discover a gun shot wound.



As a forensic anthropologist in training you can never predict what remains will be presented to you in a case. Therefore knowledge of the entire skeleton is essential.

Our unique collection of juvenile remains at the university enables us to be in a great position for learning about skeletal development from a practical point of view. However, with the number of students handling these increasing every year, damage will soon follow. Preservation of these fragile elements is essential and by 3D scanning combined with a teaching package, they will be freely accessible to students without subjecting the bones to any damage.

This online tutorial package will not be up and running before your time as an undergraduate here at the University of Dundee is over, however elements of it will become available to you and I need your help evaluating my work. A series of tests and tutorials will be coming your way over the next year for you to take part in and evaluate, these will take up very little time and may even help you when it comes to revising and give some of you a head start in forensic anthropology!

If you require any further information into my research please don't hesitate to ask: ktyldesley@dundee.ac.uk

Instructions for Pre test and evaluation 1

The links below (developmental osteology pre test and juvenile pretest) should be taken without any prior study. This module is being created for level three therefore I expect low pass rates from lower levels. It is important for my research to answer to the best of your knowledge without looking up any answers or guessing.
Don't worry about your scores, they will not be used for anything else and there's no need to pass!
The first test (developmental osteology pre test) is split into two sections and a ten minute time limit has been set for the entire test, so please allow 5 minutes per section. The first test will be on a particular region of the skeleton in which some of you will have very little experience and others will have more.
A short evaluation will follow the test. Any suggestions / comments can be made via the discussion board or direct to my e-mail (k.tyldesley@dundee.ac.uk).
Instructions for the second test can be found under these instructions, follow these after completing the first test and evaluation.

Answer each question to the best of your knowledge (**please don't google or guess**) – this is important for my data collection. If you don't know please tick the box "don't know" or leave the question blank.

- **Note to level 1** – You are not expected to know the material you are about to be tested on therefore high pass rates are not expected. Don't worry if you don't know anything – by the end of 3rd year it will all make sense.
- **Note to Msc students** - Your backgrounds are varied, therefore pass rates will also be varied. This is expected, please remember not to guess, you can highlight in the evaluation how much background you have.

Please ensure you have completed both tests and the evaluation before this time.
YOU MUST USE **INTERNET EXPLORER** - **MOZILLA FIREFOX** WILL NOT WORK PROPERLY!

Thanks for participating!

Pre test 1 - Developmental Osteology Pre test

The juvenile test is at the bottom of the page.

Click on the above link to take the test. Please don't guess!

Evaluation 1 - Developmental Osteology Pre test evaluation

Click on the above link to begin the Developmental Osteology Pre-test Evaluation. Please complete this only once.

Evaluation 1 - Developmental Osteology Pre test evaluation

Click on the above link to begin the Developmental Osteology Pre-test Evaluation. Please complete this only once.

Instructions for Juvenile pretest

This test will be on the development of a particular region of the skeleton in which some of you will have very little experience and others will have more. I need students of different levels to undertake this test in order to create a test for the relevant level (level 3). I will therefore be expecting a range of pass rates dependent on the level at which you are currently studying – But don't worry about them, there is no need to pass!
The test is split into three sections and a 15 minute time limit has been set for the entire test, so please allow 5 minutes per section.

Answer each question to the best of your knowledge (**please don't google or guess**) – this is important for my data collection. If you don't know please tick the box "don't know" or leave the question blank.

You are welcome to email me any suggestions or comments or add them to the discussion board.

- **Note to levels 1 and 2** – You are not expected to know the material you are about to be tested on therefore high pass rates are not expected. Don't worry if you don't know anything – by the end of 3rd year it will all make sense, should also give you a head start!
- **Note to level 3, 4 and staff** – The content of this test should be familiar to you, therefore it is essential to this study to know if there are any difficulties or problems with the test.
- **Note to Msc students** - Your backgrounds are varied, therefore pass rates will also be varied. This is expected, please remember not to guess, you can highlight in the evaluation how much background you have.

Please ensure you have completed both before this time.
YOU MUST USE **INTERNET EXPLORER** - **MOZILLA FIREFOX** WILL NOT WORK PROPERLY!

Thanks for participating!

Pre test 2 - Developmental Osteology Juvenile Pre test

Developmental osteology pre test 1 and test 1 GROUPS

Participan	Status 1	Total scor	Maximum	Pre test 1	Status 2	Total scor	Maximum	Test 1 (2)
Level 1								
	Finished no	4	44	9%	Finished no	14	44	32%
	Finished no	13	44	30%	Finished no	24	44	55%
	Finished no	5	44	11%	Finished no	37	44	84%
	Finished no	6	44	14%	Finished no	22	44	50%
	Finished no	3	44	7%	Finished no	19	44	43%
	Finished no	2	44	5%	Finished no	19	44	43%
	Finished no	4	44	9%	Time limit e	0	25	0%
	Finished no	6	44	14%	Finished no	26	44	59%
	Finished no	14	44	32%	Assessmer	25	44	57%
	Finished no	6	44	14%	Finished no	11	44	25%
	Finished no	0	44	0%	Finished no	12	44	27%
	Finished no	0	44	0%	Finished no	27	44	61%
	Finished no	5	44	11%	Finished no	25	44	57%
	Finished no	11	44	25%	Finished no	24	44	55%
	Finished no	1	44	2%	Finished no	18	44	41%
	Finished no	4	44	9%	Finished no	23	44	52%
	Finished no	5	44	11%	Finished no	19	44	43%
	Finished no	9	44	20%	Finished no	18	44	41%
	Finished no	5	44	11%	Finished no	23	44	52%
	Finished no	1	44	2%	Finished no	23	44	52%
	Finished no	1	44	2%	Finished no	12	44	27%
	Finished no	5	44	11%	Finished no	17	44	39%
	Finished no	4	44	9%	Assessmer	16	44	36%
	Finished no	7	44	16%	Finished no	13	44	30%
	Finished no	9	44	20%	Finished no	20	44	45%
	Finished no	11	44	25%	Finished no	33	44	75%
	Finished no	2	44	5%	Finished no	18	44	41%
	Finished no	2	44	5%	Finished no	19	44	43%
	Finished no	19	44	43%	Finished no	16	44	36%
	Finished no	7	44	16%	Finished no	26	44	59%
	Assessmer	6	44	14%	Finished no	15	44	34%
	Finished no	12	44	27%	Finished no	22	44	50%
	Finished no	5	44	11%	Finished no	25	44	57%
Level 2								
	Finished no	4	44	9%	Finished no	16	44	36%
	Finished no	12	44	27%	Finished no	22	44	50%
	Finished no	5	44	11%	Finished no	29	44	66%
	Finished no	2	44	5%	Finished no	24	44	55%
	Finished no	5	44	11%	Finished no	22	44	50%
	Finished no	0	44	0%	Finished no	6	44	14%
	Finished no	7	44	16%	Finished no	24	44	55%
	Finished no	5	44	11%	Finished no	14	44	32%
	Assessmer	12	44	27%	Finished no	23	44	52%
	Finished no	21	44	48%	Finished no	31	44	70%
	Finished no	8	44	18%	Assessmer	17	44	39%
	Finished no	5	44	11%	Assessmer	25	44	57%

	Finished no	2	44	5%	Assessmen	18	44	41%
	Finished no	21	44	48%	Finished no	38	44	86%
	Finished no	10	44	23%	Finished no	35	44	80%
	Finished no	8	44	18%	Finished no	21	44	48%
	Finished no	6	44	14%	Finished no	22	44	50%
Level 3								
	Finished no	7	44	16%	Finished no	37	44	84%
	Finished no	5	44	11%	Finished no	34	44	77%
	Finished no	6	44	14%	Finished no	38	44	86%
	Finished no	0	44	0%	Finished no	30	44	68%
	Finished no	2	44	5%	Finished no	35	44	80%
	Finished no	18	44	41%	Finished no	35	44	80%
	Finished no	10	44	23%	Finished no	38	44	86%
	Finished no	3	44	7%	Assessmen	24	44	55%
	Finished no	6	44	14%	Finished no	41	44	93%
	Finished no	2	44	5%	Finished no	35	44	80%
	Finished no	5	44	11%	Finished no	26	44	59%
	Finished no	3	44	7%	Assessmen	32	44	73%
	Assessmen	13	44	30%	Finished no	36	44	82%
	Finished no	10	44	23%	Finished no	41	44	93%
	Finished no	3	44	7%	Finished no	39	44	89%
	Finished no	3	44	7%	Finished no	37	44	84%
	Finished no	6	44	14%	Finished no	34	44	77%
	Finished no	4	44	9%	Finished no	33	44	75%
	Finished no	9	44	20%	Finished no	37	44	84%
	Finished no	27	44	61%	Finished no	32	44	73%
	Finished no	3	44	7%	Finished no	34	44	77%
	Finished no	3	44	7%	Finished no	35	44	80%
	Finished no	5	44	11%	Finished no	39	44	89%
	Finished no	1	44	2%	Finished no	34	44	77%
	Finished no	25	44	57%	Finished no	36	44	82%
	Finished no	7	44	16%	Finished no	39	44	89%
Level 4								
	Finished no	36	44	82%	Finished no	42	44	95%
	Finished no	23	44	52%	Finished no	37	44	84%
	Finished no	28	44	64%	Finished no	41	44	93%
	Finished no	17	44	39%	Finished no	37	44	84%
	Finished no	37	44	84%	Finished no	36	44	82%
	Finished no	29	44	66%	Finished no	37	44	84%
	Finished no	33	44	75%	Finished no	38	44	86%
	Finished no	34	44	77%	Finished no	40	44	91%
	Finished no	36	44	82%	Finished no	39	44	89%
	Finished no	35	44	80%	Finished no	36	44	82%
	Finished no	22	44	50%	Finished no	38	44	86%
	Finished no	34	44	77%	Finished no	35	44	80%
	Finished no	16	44	36%	Finished no	40	44	91%
	Finished no	35	44	80%	Finished no	39	44	89%
	Finished no	34	44	77%	Finished no	41	44	93%
	Finished no	32	44	73%	Finished no	38	44	86%
	Finished no	17	44	39%	Finished no	41	44	93%
	Assessmen	28	44	64%	Finished no	41	44	93%
	Finished no	35	44	80%	Finished no	39	44	89%
	Assessmen	30	44	68%	Finished no	38	44	86%

	Finished no	36	44	82%	Finished no	38	44	86%
Staff / Postg-rad								
Some/ a lot of experience (over to 70%)								
	Finished no	42	44	95%	Finished no	39	44	89%
	Finished no	34	44	77%	Finished no	37	44	84%
	Finished no	43	44	98%	Finished no	43	44	98%
	Finished no	33	44	75%	Finished no	38	44	86%
	Finished no	39	44	89%	Finished no	35	44	80%
	Finished no	37	44	84%	Finished no	38	44	86%
	Finished no	37	44	84%	Finished no	37	44	84%
	Finished no	33	44	75%	Finished no	37	44	84%
	Finished no	34	44	77%	Finished no	35	44	80%
	Finished no	38	44	86%	Finished no	38	44	86%
	Finished no	40	44	91%	Finished no	43	44	98%
	Finished no	42	44	95%	Finished no	43	44	98%
	Finished no	39	44	89%	Finished no	38	44	86%
	Finished no	41	44	93%	Finished no	42	44	95%
Little / no experience								
	Finished no	19	44	43%	Finished no	36	44	82%
	Finished no	1	44	2%	Assessmen	20	44	45%
	Finished no	4	44	9%	Assessmen	21	44	48%
	Finished no	4	44	9%	Assessmen	20	44	45%
	Finished no	22	44	50%	Finished no	30	44	68%
	Finished no	23	44	52%	Finished no	33	44	75%
	Finished no	30	44	68%	Finished no	36	44	82%

Section 1

Question 1: Is this skeleton in the anatomical position?				Question 2: The innominate (also known as the hip bone or os coxae) can be palpated through skin and soft tissues.				Question 3: pelvic girdle
Answer 1	**Score 1**	**Answer 2**	**Score 2**	**Answer 1**	**Score 1**	**Answer 2**	**Score 2**	**Answer 1**
No	1	Yes	0	TRUE	1	TRUE	1	Don't know
No	1	No	1	TRUE	1	TRUE	1	Right and l
No	1	No	1	Don't know	0	TRUE	1	Don't know
Don't know	0	Yes	0	Don't know	0	TRUE	1	Don't know
No	1	Yes	0	Don't know	0	FALSE	0	Don't know
Don't know	0	Yes	0	TRUE	1	TRUE	1	Don't know
No	1		0	Don't know	0		0	Don't know
Don't know	0	Yes	0	Don't know	0	TRUE	1	Don't know
Yes	0	Yes	0	TRUE	1	TRUE	1	Lumbar Ve
No	1	No	1	Don't know	0	TRUE	1	Don't know
Don't know	0	Yes	0	Don't know	0	TRUE	1	Don't know
Yes	0	Yes	0	Don't know	0	TRUE	1	Don't know
No	1	No	1	FALSE	0	TRUE	1	Right and l
Yes	0	No	1	Don't know	0	TRUE	1	Coccyx:Rig
No	1	No	1	FALSE	0	FALSE	0	Don't know
No	1	Yes	0	Don't know	0	TRUE	1	Don't know
No	1	Yes	0	Don't know	0	TRUE	1	Don't know
No	1	Yes	0	TRUE	1	FALSE	0	Right and l
Don't know	0	No	1	Don't know	0	TRUE	1	Coccyx
No	1	No	1	Don't know	0	TRUE	1	Don't know
No	1	No	1	Don't know	0	TRUE	1	Don't know
No	1	No	1	Don't know	0	TRUE	1	Coccyx
Don't know	0	Don't know	0	Don't know	0	TRUE	1	Don't know
No	1	Yes	0	Don't know	0	TRUE	1	Coccyx:Sa
No	1	No	1	Don't know	0	TRUE	1	Don't know
No	1	No	1	Don't know	0	TRUE	1	Coccyx:Sa
Don't know	0	Yes	0	Don't know	0	TRUE	1	Don't know
Don't know	0	No	1	Don't know	0	TRUE	1	Coccyx
No	1	Yes	0	TRUE	1	TRUE	1	Right and l
No	1	No	1	Don't know	0	TRUE	1	Right and l
No	1	Yes	0	TRUE	1	TRUE	1	Don't know
No	1	Yes	0	Don't know	0	Don't know	0	Right and l
No	1	No	1	TRUE	1	TRUE	1	Don't know
No	1	Yes	0	TRUE	1	TRUE	1	Don't know
No	1	Yes	0	FALSE	0	FALSE	0	Don't know
No	1	No	1	TRUE	1	TRUE	1	Right and l
Don't know	0	No	1	Don't know	0	FALSE	0	Don't know
No	1	No	1	Don't know	0	TRUE	1	Don't know
Don't know	0	No	1	Don't know	0	Don't know	0	Don't know
Yes	0	No	1	Don't know	0	Don't know	0	Don't know
No	1	Don't know	0	TRUE	1	TRUE	1	Don't know
No	1	Yes	0	TRUE	1	FALSE	0	Don't know
Yes	0	Yes	0	TRUE	1	Don't know	0	Right and l
No	1	Yes	0	Don't know	0	TRUE	1	Right and l
Yes	0	No	1	TRUE	1	TRUE	1	Don't know

No	1	No	1	Don't know	0	FALSE	0	Don't know
No	1	No	1	Don't know	0	TRUE	1	Right and l
No	1	No	1	FALSE	0	TRUE	1	Don't know
Yes	0	Yes	0	TRUE	1	FALSE	0	Don't know
No	1	No	1	Don't know	0	TRUE	1	Don't know
No	1	No	1	Don't know	0	TRUE	1	Coccyx
Yes	0	No	1	Don't know	0	TRUE	1	Don't know
No	1	No	1	TRUE	1	TRUE	1	Right and l
Don't know	0	No	1	Don't know	0	TRUE	1	Don't know
Don't know	0	No	1	Don't know	0	FALSE	0	Don't know
No	1	No	1	TRUE	1	TRUE	1	Right and l
No	1	No	1	FALSE	0	TRUE	1	Right and l
Yes	0	No	1	Don't know	0	TRUE	1	Right and l
No	1	No	1	Don't know	0	TRUE	1	Don't know
Don't know	0	No	1	TRUE	1	TRUE	1	Don't know
Don't know	0	No	1	Don't know	0	FALSE	0	Right and l
No	1	No	1	Don't know	0	TRUE	1	Don't know
No	1	No	1	TRUE	1	TRUE	1	Right and l
No	1	No	1	Don't know	0	TRUE	1	Right and l
No	1	No	1	Don't know	0	TRUE	1	Coccyx
Don't know	0	No	1	Don't know	0	TRUE	1	Don't know
No	1	No	1	Don't know	0	TRUE	1	Don't know
Don't know	0	No	1	TRUE	1	TRUE	1	Don't know
Don't know	0	No	1	Don't know	0	TRUE	1	Right and l
Yes	0	No	1	TRUE	1	TRUE	1	Coccyx:Sa
No	1	No	1	Don't know	0	TRUE	1	Don't know
Don't know	0	No	1	Don't know	0	TRUE	1	Sacrum
No	1	No	1	Don't know	0	TRUE	1	Don't know
Yes	0	No	1	Don't know	0	TRUE	1	Don't know
Yes	0	No	1	Don't know	0	TRUE	1	Right and l
No	1	No	1	TRUE	1	TRUE	1	Don't know
No	1	No	1	TRUE	1	TRUE	1	Sacrum:Co
No	1	No	1	TRUE	1	TRUE	1	Right and l
No	1	No	1	TRUE	1	TRUE	1	Right and l
No	1	No	1	TRUE	1	TRUE	1	Sacrum:Rig
No	1	No	1	TRUE	1	TRUE	1	Right and l
No	1	No	1	TRUE	1	TRUE	1	Sacrum:Rig
No	1	No	1	TRUE	1	TRUE	1	Right and l
No	1	No	1	TRUE	1	TRUE	1	Coccyx:Rig
No	1	No	1	TRUE	1	TRUE	1	Right and l
No	1	No	1	TRUE	1	TRUE	1	Sacrum:Rig
No	1	No	1	Don't know	0	TRUE	1	Sacrum:Co
No	1	No	1	TRUE	1	TRUE	1	Sacrum:Co
No	1	No	1	TRUE	1	TRUE	1	Right and l
No	1	No	1	TRUE	1	TRUE	1	Sacrum:Co
No	1	No	1	TRUE	1	TRUE	1	Right and l
No	1	No	1	TRUE	1	TRUE	1	Sacrum:Rig
No	1	No	1	TRUE	1	TRUE	1	Lumbar Ve
No	1	No	1	TRUE	1	TRUE	1	Right and l
No	1	No	1	TRUE	1	TRUE	1	Coccyx:Rig
No	1	No	1	TRUE	1	TRUE	1	Right and l

No	1	No	1	TRUE	1	TRUE	1	Coccyx:Sa
No	1	No	1	TRUE	1	TRUE	1	Coccyx:Rig
No	1	No	1	TRUE	1	TRUE	1	Coccyx:Sa
No	1	No	1	TRUE	1	TRUE	1	Sacrum:Ri
No	1	No	1	TRUE	1	TRUE	1	Sacrum:Ri
No	1	No	1	TRUE	1	TRUE	1	Sacrum:Ri
No	1	No	1	TRUE	1	TRUE	1	Right and l
No	1	No	1	TRUE	1	TRUE	1	Coccyx:Sa
No	1	No	1	TRUE	1	TRUE	1	Sacrum:Ri
No	1	No	1	TRUE	1	TRUE	1	Right and l
No	1	No	1	TRUE	1	TRUE	1	Sacrum:Ri
No	1	No	1	TRUE	1	TRUE	1	Right and l
No	1	No	1	TRUE	1	TRUE	1	Sacrum:Co
No	1	No	1	TRUE	1	TRUE	1	Right and l
No	1	No	1	TRUE	1	TRUE	1	Right and l
Yes	0	No	1	TRUE	1	TRUE	1	Right and l
No	1	Yes	0	Don't know	0	FALSE	0	Don't know
Yes	0	Yes	0	Don't know	0	TRUE	1	Coccyx:Do
No	1	No	1	TRUE	1	TRUE	1	Lumbar Ve
Yes	0	Yes	0	TRUE	1	TRUE	1	Sacrum:Co
Don't know	0	Yes	0	TRUE	1	TRUE	1	Sacrum
No	1	No	1	TRUE	1	TRUE	1	Right and l

: Which of these contribute to the e?			Question 4: Drag these labels to their bony landmark(If you don't know please leave unanswered)				Question 5: Define the	
Score 1	**Answer 2**	**Score 2**	**Answer 1**	**Score 1**	**Answer 2**	**Score 2**	**Answer 1**	**Score 1**
0	Right and l	1		0	600,164:93	4	don't know	0
1	Coccyx:Sa	3	192,45:100	0	91,169:626	1	don't know	2
0	Coccyx:Rig	3	:228,36:76	0	600,168:88	4	don't know	0
0	Coccyx	1		0	95,256:626	1	don't know	2
0	Sacrum:Co	3	228,21::15	0	75,170:88,	2	don't know	0
0	Right and l	2		0	89,254:626	2	don't know	0
0		0		0		0	don't know	0
0	Coccyx	1	76,36:62,5	0	600,169:99	4	don't know	2
2	Coccyx:Rig	3	600,173:10	2	600,164:79	4	don't know	1
0	Sacrum:Co	2		0		0	mixed joint	1
0	Coccyx:Rig	3	:68,29::	0	87,168:626	0	don't know	0
0	Right and l	3		0	600,168:10	4	don't know	0
1	Coccyx:Rig	2		0	600,168:62	2	don't know	0
2	Right and l	1		0	600,229:89	2	don't know	2
0	Right and l	3		0		0	don't know	0
0	Right and l	1	:::57,16	0	88,170:626	0	don't know	0
0	Right and l	2	:73,22:133	0		0	cartilaginou	1
1	Right and l	3		0		0	synovial joi	2
1	Sacrum:Co	3		0	600,174:87	4	don't know	1
0	Coccyx:Rig	3	219,22:63,	0	600,173:62	2	don't know	0
0	Coccyx:Sa	3	102,16:118	0		0	don't know	0
1	Coccyx:Rig	3	75,51:62,3	0		0	::cartilagino	0
0	Right and l	3	:149,102:1	0	600,167:88	4	don't know	0
2	Don't know	0		0	90,262:626	2	mixed joint	2
0	Sacrum	1	89,168:68,	0	600,162:84	4	don't know	1
3	Right and l	3	:62,41:50,7	0	600,168:85	4	don't know	0
0	Sacrum:Co	3		0	91,258:626	1	::synovial j	1
1	Right and l	3		0		0	don't know	0
0	Right and l	1	600,223:82	2	93,261:626	1	synovial joi	0
2	Sacrum:Co	2	:62,27:158	0	92,262:626	2	don't know	0
0	Sacrum:Rig	2	89,173:626	0	91,257:81,	0	don't know	1
1	Right and l	3		0	517,319:::7	1	synovial joi	0
0	Coccyx:Sa	3		0	600,227:10	1	don't know	0
0	Sacrum:Co	3		0	600,169:::	1	don't know	0
0	Sacrum:Rig	3	75,319:::	0	600,168:96	4	don't know	0
1	Right and l	2		0	600,164:89	4	don't know	0
0	Coccyx:Rig	3		0	600,159:90	4	don't know	0
0	Don't know	0		0	600,166:62	2	don't know	0
0	Don't know	0		0		0	don't know	0
0	Coccyx:Sa	3	76,319:::	0	:::101,169	1	cartilaginou	0
0	Right and l	3		0		0		0
0	Right and l	3		0	600,167::6	3	::synovial j	1
2	Right and l	3	600,168:10	1	600,164:90	4	cartilaginou	3
2	Sacrum:Rig	3		0	600,167:92	4	::synovial j	1
0	Right and l	3		0	600,168:85	4	cartilaginou	1

0	Coccyx:Sa	3	600,164:::	1	600,164:89	4	don't know	0
1	Right and l	3	600,165:10	4	600,167:86	4	don't know	0
0	Sacrum:Rig	3	600,226:89	0	600,169:86	4	don't know	1
0	Don't know	0				0	cartilaginou	0
0	Coccyx:Sa	3		0	::650,228:	1	:cartilagino	2
1	Right and l	3	75,319:::	0	600,165:95	4	don't know	1
0	Sacrum:Rig	3		0	600,165:62	2	don't know	1
1	Right and l	2		0	600,167:83	4	don't know	0
0	Right and l	1		0	600,166:10	4	don't know	0
0	Coccyx:Rig	3		0	600,169:62	2	don't know	0
1	Right and l	3	90,170:626	1	600,172:62	2	don't know	1
0	Coccyx:Rig	3		0	600,167:84	4	synovial joi	2
1	Coccyx:Sa	3		0	600,164:62	2	don't know	0
0	Sacrum:Co	3		0	600,169:85	4	don't know	1
0	Right and l	3		0	600,164:85	4	don't know	0
2	Right and l	3		0	600,167:62	2	don't know	0
0	Right and l	3	NaN,NaN:N	0	600,165:62	2	don't know	0
2	Sacrum:Co	3	97,260:79,	1	600,164:95	4	synovial joi	3
2	Sacrum:Rig	3		0	600,166:84	4	don't know	1
1	Sacrum:Rig	3	NaN,NaN:N	0	600,165:83	4	don't know	0
0	Right and l	3		0	600,164:62	2	don't know	0
0	Coccyx:Rig	3	:NaN,NaN:	0	600,170:62	2	cartilaginou	1
0	Right and l	1		0	600,162:91	4	don't know	0
2	Sacrum:Rig	3	87,170:108	1	600,170:93	4	don't know	0
3	Right and l	2	89,167:98,	2	600,166:92	4	cartilaginou	2
0	Right and l	3	76,319:::	0	600,164:88	4	don't know	0
1	Right and l	2		0	600,161:97	4	don't know	1
0	Right and l	3		0	600,167:91	4	don't know	1
0	Right and l	3		0	600,164:86	4	don't know	1
3	Right and l	1	600,166:92	2	600,168:87	4	mixed joint	2
0	Coccyx:Sa	3	NaN,NaN:N	0	600,169:90	4	don't know	2
3	Right and l	3	600,165:93	4	600,166:94	4	synovial joi	2
2	Coccyx:Rig	3	600,167:62	2	600,168:90	4	synovial joi	2
1	Sacrum:Rig	3	88,168:626	0	600,167:88	4	don't know	2
2	Right and l	3	NaN,NaN:N	0	600,164:87	4	synovial joi	2
1	Right and l	3	600,164:90	4	600,165:10	4	cartilaginou	3
2	Coccyx:Rig	3	600,168:62	2	600,168:89	4	synovial joi	1
1	Right and l	3	600,171:76	4	600,164:87	4	synovial joi	1
3	Sacrum:Rig	3	600,166:62	2	600,167:88	4	cartilaginou	3
3	Sacrum:Co	3	600,164:62	2	600,166:84	4	cartilaginou	2
3	Right and l	1	600,167:89	4		0	synovial joi	1
2	Sacrum:Co	3	600,167:89	1	600,167:62	2	cartilaginou	2
3	Sacrum:Co	3	600,170:83	4	600,168:92	4	cartilaginou	0
1	Coccyx:Sa	3		0	600,169:92	4	don't know	0
3	Coccyx:Sa	3	600,167:62	2	600,166:81	4	synovial joi	2
1	Coccyx:Sa	3	600,167:62	2	600,165:90	4	synovial joi	2
2	Sacrum:Rig	2	600,167:62	2	600,165:90	4	synovial joi	2
2	Coccyx:Sa	3	77,319:::	0	600,168:98	4	don't know	2
2	Sacrum:Rig	3	:626,224::8	1	600,165:88	4	synovial joi	1
3	Right and l	2	600,168:92	4	600,169:83	4	synovial joi	2
1	Coccyx:Rig	3	600,169:62	2	600,170:62	2	synovial joi	3

3	Coccyx:Rig	3	600,166:62	2	600,170:81	4	synovial joi	2
3	Sacrum:Co	3	600,167:95	4	600,160:10	4	mixed joint	3
3	Coccyx:Sa	3	600,166:90	4	600,165:91	4	cartilaginou	2
3	Coccyx:Rig	3	600,167:86	4	600,167:88	4	mixed joint	3
2	Right and l	3	600,163:94	4	600,165:90	4	cartilaginou	3
3	Sacrum:Rig	2	600,164:88	4	600,166:81	4	synovial joi	3
3	Right and l	2	600,165:83	4	600,165:95	4	cartilaginou	3
3	Right and l	2	600,170:97	4	600,167:10	4	synovial joi	3
2	Sacrum:Co	3	600,167:88	4	600,168:88	4	cartilaginou	2
2	Sacrum:Co	3	600,166:62	2	600,164:62	2	mixed joint	3
2	Right and l	2	600,168:88	4	600,166:10	4	synovial joi	2
1	Sacrum:Rig	3	600,166:95	4	600,168:88	4	mixed joint	3
3	Right and l	3	600,166:90	4	600,167:93	4	synovial joi	2
2	Sacrum:Co	3	600,168:97	4	600,165:91	4	cartilaginou	3
2	Right and l	2	600,168:90	4	600,168:93	4	synovial joi	2
2	Coccyx:Rig	3	NaN,NaN:N	0	600,166:88	4	cartilaginou	3
0	Sacrum:Rig	3		0	600,167:83	4	don't know	0
1	Coccyx:Sa	3	75,10:::50,	0	600,166:87	4	don't know	0
0	Right and l	2	:62,74:50,3	0	600,225:::	0	:cartilagino	1
3	Coccyx:Sa	3	600,167:62	2	600,169:62	2	don't know	2
1	Sacrum:Co	2	600,162:74	4	600,168:93	4	don't know	2
3	Right and l	3	600,164:11	4	600,168:10	4	cartilaginou	1

following joints		Question 6: Drag these labels to their site on the right innominate (If you don't know please leave unanswered)				Question 7: The right innominate a with the _____ posteriorly and the innominate anteriorly.		
Answer 2	**Score 2**	**Answer 1**	**Score 1**	**Answer 2**	**Score 2**	**Answer 1**	**Score 1**	**Answer 2**
mixed joint	2		0	129,127:12	0		0	left:right
synovial joi	2	101,68:234	0	125,424:54	3		0	
mixed joint	4		0	133,424:54	3		0	sacrum:left
cartilaginou	1		0	128,421:12	1		0	
don't know	0	222,27:200	0	120,422:54	3		0	
cartilaginou	1		0	128,425:54	3		0	
	0		0		0		0	
::synovial j	1	161,35:543	0	133,425:54	3		0	
don't know	1	543,422:13	1	117,423:54	3		0	
don't know	0		0		0		0	
synovial joi	0		0	132,122:14	0		0	
mixed joint	3		0		0		0	
cartilaginou	2		0	128,423:54	3		0	
cartilaginou	1	128,424:54	3	123,426:54	3		0	
don't know	0		0		0		0	
synovial joi	2		0	124,421:54	3		0	superior:inf
cartilaginou	1		0	127,426:54	3		0	
don't know	0		0	127,425:54	3		0	
don't know	1	:229,48:69,	0		0		0	
cartilaginou	1		0	129,423:54	3		0	
don't know	1		0		0		0	
don't know	2	84,35:83,6(	0	124,420:54	3		0	
don't know	3	543,423:13	0	129,426:30	1		0	
synovial joi	1	193,42:170	0		0		0	
synovial joi	3	543,427:13	1	118,130:12	0		0	left:right
synovial joi	3	129,426:54	3	111,426:13	1		0	
synovial joi	1		0	133,425::	1		0	
don't know	1		0	124,420:13	1		0	
synovial joi	1	122,430:54	3	135,421:54	3		0	
mixed joint	1	543,424:13	0	131,423:54	3		0	
cartilaginou	1	:543,422:	1		0		0	
don't know	0	132,424:54	3	126,426:54	3		0	
mixed joint	1		0	118,423:54	3		0	
synovial joi	0		0		0		0	
synovial joi	2		0	129,131:12	0		0	
synovial joi	1	124,56:330	0	117,421:54	3		0	sacrum:left
don't know	0		0		0		0	
don't know	1		0	128,424:25	1		0	
don't know	0		0		0		0	
don't know	0	135,423:54	3	543,423:13	1		0	
don't know	0		0		0		0	
don't know	0		0	128,425:12	1		0	
mixed joint	3	122,426::	1	130,424:54	3		0	sacrum:left
cartilaginou	1		0	129,428:54	3		0	iliac:left
synovial joi	3		0		0		0	lower limbs

don't know	1		0	126,428:54	3		0	
mixed joint	3	126,425:54	3	129,425:12	1	:left	1	sacrum:left
synovial joi	3	120,425:54	3	134,423:54	3	:left	1	
cartilaginou	1	543,432:14	1	117,425:54	3		0	
synovial joi	1		0	128,130:54	1		0	
synovial joi	2		0	124,424:54	3		0	sacrum:left
don't know	2		0	129,423:54	3		0	
mixed joint	3		0	132,422:54	3		0	sacrum:left
cartilaginou	2		0	126,425:54	3		0	sacrum:left
mixed joint	3		0	125,419:54	3		0	sacrum:left
cartilaginou	2	122,427:12	1	117,421:54	3		0	sacrum:left
cartilaginou	3	::370,454	0	131,425:54	3		0	sacral:left
mixed joint	4		0	543,426:14	1		0	sacrum:left
mixed joint	3		0	129,425:54	3		0	sacrum:left
synovial joi	2		0	135,425:54	3		0	sacrum:left
cartilaginou	1		0	127,423:54	3		0	sacrum:iliu
synovial joi	1		0	127,423:54	3		0	sacrum:left
synovial joi	3	108,418:11	1	136,423:54	3	:left	1	sacrum:left
mixed joint	3	129,129:13	0	125,426:54	3	:left	1	sacrum:left
synovial joi	3	:NaN,NaN:	0	119,424:54	3		0	sacrum:left
synovial joi	1		0	129,427:54	3		0	sacrum:left
don't know	2	NaN,NaN:N	0	126,424:54	3		0	
synovial joi	1		0	122,425:54	3		0	sacrum:left
mixed joint	3	86,454:283	1	127,425:54	3		0	sacrum:left
synovial joi	2	125,425:54	3	126,424:54	3		0	:left
don't know	2		0	128,426:54	3		0	
synovial joi	2		0	130,425:54	3		0	
mixed joint	3		0	124,423:54	3		0	sacrum:left
cartilaginou	3		0	131,430:54	3		0	
cartilaginou	2	543,426:12	1	117,424:54	3		0	sacrum:left
mixed joint	4	:NaN,NaN:	0	126,422:54	3		0	sacrum:left
mixed joint	3	134,421:54	3	128,426:54	3	sacrum:left	2	sacrum:left
mixed joint	2	127,423:54	3	124,427:54	3	sacrum:	1	sacrum:left
mixed joint	3	131,429:54	3	126,424:54	3	sacrum:left	2	sacrum:left
synovial joi	2	NaN,NaN:N	0	138,424:54	3		0	sacrum:left
mixed joint	3	129,423:54	3	132,421:54	3	sacrum:left	2	sacrun:left
synovial joi	2	123,422:54	3	125,422:54	3	sacrum:ant	1	sacrum:left
mixed joint	4	117,426:54	3	128,427:54	3	sacrum:pul	1	sacrum:left
synovial joi	3	127,426:54	3	130,425:54	3	sacrum:left	2	sacrum:left
mixed joint	3	129,423:54	3	124,424:54	3	sacrum:left	2	sacrum:left
mixed joint	3	132,423:54	3	127,423:54	3	sacrum:left	2	sacrum:left
mixed joint	4	134,424:54	3	125,426:54	3		0	sacrum:left
synovial joi	1	123,424:54	3	121,424:54	3	sacrum:left	2	sacrum:left
synovial joi	3	129,425:54	3	126,425:54	3	sacrum:left	2	sacrum:left
mixed joint	3	121,427:54	3	133,425:54	3	sacrum:left	1	sacrum:left
mixed joint	4	129,425:54	3	123,428:54	3	sacrum:left	2	sacrum:left
synovial joi	2	138,425:54	3	129,425:54	3	sacrum:left	2	sacrum:left
mixed joint	3	132,424::	1	132,425:54	3	:left	1	sacrum:left
synovial joi	2	124,430:54	3	126,424:54	3	sacrum:left	2	sacrum:left
mixed joint	3	126,429:54	3	127,422:54	3	Sacrum:Le	0	sacrum:left
synovial joi	2	132,428:54	3	126,423:54	3	sacrum:pul	1	sacrum:left

synovial joi	2	133,426:54	3	121,428:54	3	sacrum:left	2	sacrum:left
mixed joint	3	134,431:54	3	126,419:54	3	sacrum:left	2	sacrum:left
cartilaginou	2	129,426:54	3	129,425:54	3	Sacrum:Le	0	sacrum:left
mixed joint	3	127,425:54	3	127,427:54	3	sacrum:left	2	sacrum:left
synovial joi	1	127,423:54	3	121,425:54	3	sacrum:left	2	sacrum:left
synovial joi	2	119,421:54	3	128,425:54	3	sacrum:left	2	sacrum:left
synovial joi	2	126,426:54	3	128,423:54	3	sacrum:left	2	sacrum:left
synovial joi	2	123,422:54	3	124,424:54	3	sacrum:left	2	sacrum:left
cartilaginou	2	125,421:54	3	131,424:54	3	sacrum:left	2	sacrum:left
mixed joint	2	129,422:54	3	129,425:54	3	sacrum:left	2	sacrum:left
synovial joi	2	126,425:54	3	139,420:54	3	sacrum:left	2	sacrum:left
mixed joint	4	131,427:54	3	121,423:54	3	sacrum:left	2	sacrum:left
synovial joi	3	131,426:54	3	129,425:54	3	sacrum:left	2	sacrum:left
synovial joi	2	132,423:54	3	125,424:54	3	sacrum:left	2	sacrum:left
mixed joint	3	132,425:54	3	126,424:54	3	sacrum:left	2	sacrum:left
mixed joint	3	NaN,NaN:N	0	135,423:54	3	sacrum:left	2	sacrum:left
synovial joi	1		0	128,426:12	1		0	
synovial joi	1		0	137,423:54	3		0	coxix:left
cartilaginou	2		0	119,421::	1		0	
synovial joi	2	130,425:54	3	122,423:54	3	pelvis:femu	0	ilium:ishiun
mixed joint	3	123,423:54	3	128,422:54	3		0	Sacrum:lef
mixed joint	3	132,424:54	3	130,423:54	3	sacrum:left	2	sacrum:left

rticulates ____	Question 8: Drag the following muscles to their attachment (If you don't know please leave unanswered)				Question 9: The shape of the adult female pelvis reflects a compromise between 2 major functions _____locomotion and safe parturition.			
Score 2	Answer 1	Score 1	Answer 2	Score 2	Answer 1	Score 1	Answer 2	Score 2
0		0	96,83:484,	0		0		0
0	:210,49:40	0		0		0		0
2	:283,18:99	0		0		0		0
0		0	103,83:98,	1		0		0
0	100,83:484	0	104,84:484	0		0	bipedal	1
0		0		0		0		0
0		0		0		0		0
0	102,81:484	0	102,86:484	0		0	bipedal	1
0	:98,47:261	0	106,77:484	0		0		0
0	::110,9	0		0		0		0
0		0		0		0		0
0		0	101,85:484	0		0	bipedal	1
0		0	100,86:484	0		0		0
0		0	484,85:94,	1		0		0
0		0		0		0		0
0		0		0		0		0
0		0		0		0		0
0	::87,31	0		0	aquatic	0		0
0	:290,9:129	0	98,85:484,	0		0		0
0		0	98,82:484,	0		0	of	0
0	98,29:484,	0		0		0		0
0		0	99,85:484,	0		0		0
0	:246,41:32	0		0		0		0
0		0		0		0		0
0	99,80:484,	0	95,72:484,	0		0		0
0	484,86:104	1		0		0	bipedal	1
0		0		0		0		0
0		0	101,89:484	0		0		0
0	109,98:484	0	113,86:484	0	birth	0	upright	0
0	103,83:484	0	99,85:484,	0		0	bipedal	1
0	112,88:484	0		0		0		0
0	100,87:484	0	102,86:484	0		0		0
0		0	103,88:102	1		0		0
0	100,85:484	0	103,81:484	0		0	bipedal	1
0		0	100,84:484	0		0		0
2	:401,9:236	0	484,82:103	1		0		0
0		0		0		0		0
0	100,83::41	0	110,89:484	0		0		0
0		0		0		0		0
0	102,80:484	0	100,89:484	0		0		0
0	100,82:484	0	98,85:484,	0		0		0
0	101,87:484	0		0		0		0
2	99,84:484,	0	98,87:484,	0	easy	0	ease of	0
1		0	98,87:98,4	1		0	birth	0
0		0		0		0	bipedal	1

0		0	103,80:103	1		0		0
2	109,88:484	0	99,85:484,	0		0	bipedal	1
0		0	102,86:484	0		0		0
		0		0		0		0
0		0		0		0		0
2		0	100,82:484	0		0	bipedal	1
0		0	103,85:484	0		0	bipedal	1
2		0	107,86:484	0	bipedal	1	bipedal	1
2		0	112,81:484	0		0		0
2		0	102,86:484	0		0	posture	0
2		0	105,87:484	0		0	bipedal	1
1	102,84:484	0	307,513:48	0	bipidel	0	bipedal	1
2		0	100,86:484	0		0		0
2		0	100,417:97	3		0	bipedal	1
2		0		0		0	fetal	0
1		0	103,90:484	0		0	foetal	0
2		0	99,422:106	3		0		0
1	94,84:484,	0	484,81:97,	1		0		0
2	99,81:484,	0	484,88:95,	1		0	bipedal	1
2		0	100,86:484	0	rotational	0	fetal	0
2		0	106,419:10	3		0	bipedal	1
0	NaN,NaN:N	0		0		0	bipedal	1
2	98,84:484,	0		0		0	bipedal	1
2	100,86:484	0	106,86:484	0	pelvic	0	fetal	0
1	100,86:484	0	99,83:484,	0		0	bi-pedal	0
0		0	484,86:97,	1		0		0
0		0	99,85::	0		0		0
2	103,82:484	0	97,84:484,	0		0	bipedal	1
0		0	100,82:484	0		0		0
2	100,83:484	0		0		0		0
2	:NaN,NaN:	0	99,85:484,	0		0	bipedal	1
2	101,86:484	0	106,417:10	3	bipedal	1	bipedal	1
2	102,79:484	0	101,416:10	3	limb	0		0
2		0	100,416:10	3		0		0
2	::NaN,NaN	0	101,86:484	0		0	bipedal	1
1	484,85:124	1	484,86:98,	1	bipedal	1	bipedal	1
2	101,83:484	0	98,85:484,	0	stable	0	upright	0
2	104,88:484	0	110,87:484	0		0	bipedal	1
2	103,87:484	0	100,83:484	0	bipedal	1	bipedal	1
2	104,83:484	0	96,83:484,	0		0	bipedal	1
2	484,85:99,	1	102,419:10	3	bipedal	1	bipedal	1
2	102,84:484	0	484,85:104	1		0	bipedal	1
2	103,90:484	0	103,86:484	0	child birth	0	child birth	0
2		0	100,85:484	0		0	bipedal	1
2	102,83:191	0	101,85:484	0	stable	0	bipedal	1
2		0	484,89:104	1	bipedal	1	bipedal	1
2	107,83:484	0	100,418:10	3	easy	0	good	0
2		0	102,419:96	3		0	bipedal	1
2		0	101,416:10	3		0	bipedal	1
2	101,80:484	0	96,415:100	3	bipedal	1	bipedal	1
2	100,86:484	0	99,416:103	3		0		0

2	105,84:484	0	99,82:484,8	0	bipedal	1	bipedal	1
2	106,415:10	3	101,83:484	0	normal	0	bipedal	1
2	107,81:484	0	99,83:484,8	0	upright	0	upright	0
2	101,417:10	3	101,416:10	3	bipedal	1	bipedal	1
2	99,415:101	3	99,81:484,8	0	TRUE	0	bipedal	1
2	484,85:110	1	107,87:484	0	bipedal	1	bipedal	1
2	99,83:484,8	0	104,84:484	0	bipedal	1	bipedal	1
2	100,87:484	0	97,418:106	3	bipedal	1	bipedal	1
2	97,83:484,8	0	101,79:484	0	upright	0	bipedal	1
2	99,86:484,8	0	101,83:484	0	walking	0	posture	0
2	99,418:104	3	102,81:484	0		0	bipedal	1
2	99,417:102	3	103,411:10	3	efficient	0	bipedal	1
2	99,416:99,8	3	101,417:10	3	bipedal	1	bipedal	1
2	103,85:484	0	102,84:484	0	bipedal	1	bipedal	1
2	103,417:10	3	98,417:104	3	bipedal	1	bipedal	1
2	NaN,NaN:N	0	::415,513	0	motor	0	bipedal	1
0		0		0		0		0
1		0	98,83:484,8	0		0		0
0		0	98,90:484,8	0		0		0
0	95,89:83,11	1	96,81:484,8	0	what do yo	0		0
1	98,75:484,8	0	103,88:484	0	bipeadle	0	bipeadle	0
2	104,85:484	0	107,418:96	3	bipedal	1	bipedal	1

				Section 2				
Question 10: In development which of these fuse to create the innominate?				Question 1: Side this innominate				Question 2: left ir skeleton.
Answer 1	**Score 1**	**Answer 2**	**Score 2**	**Answer 1**	**Score 1**	**Answer 2**	**Score 2**	**Answer 1**
Don't know	0	Ilium:Ischiu	2	Don't know	0	Don't know	0	Don't know
Don't know	0	Ischium:Iliu	2	Left	0	Left	0	TRUE
Don't know	0	Ischium:Iliu	3	Right	1	Left	0	FALSE
Don't know	0	Ilium	1	Left	0	Left	0	Don't know
Don't know	0	Ilium:Ischiu	3	Don't know	0	Right	1	Don't know
Don't know	0	Acetabulun	1	Left	0	Left	0	Don't know
Don't know	0		0	Left	0			Don't know
Don't know	0	Pubis:Ilium	3	Don't know	0	Right	1	Don't know
Don't know	0	Ischium:Iliu	3	Left	0	Right	1	TRUE
Don't know	0	Ilium:Ischiu	2	Right	1	Right	1	Don't know
Don't know	0	Don't know	0	Don't know	0	Left	0	Don't know
Don't know	0	Pubis:Ilium	3	Don't know	0	Right	1	Don't know
Don't know	0	Pubis:Ilium	3	Right	1	Right	1	Don't know
Don't know	0	Pubis:Ischi	3	Right	1	Right	1	Don't know
Don't know	0	Ischium:Pu	3	Don't know	0	Don't know	0	Don't know
Don't know	0	Ischium:Iliu	3	Left	0	Left	0	Don't know
Don't know	0	Don't know	0	Don't know	0	Right	1	Don't know
Ilium:Pubis	3	Ilium:Ischiu	3	Don't know	0	Don't know	0	Don't know
Don't know	0	Ischium:Iliu	3	Left	0	Left	0	Don't know
Don't know	0	Ischium:Iliu	3	Left	0	Left	0	Don't know
Don't know	0	Trochanter	1	Don't know	0	Left	0	Don't know
Don't know	0	Don't know	0	Left	0	Left	0	Don't know
Don't know	0	Pubis:Ischi	3	Don't know	0	Don't know	0	Don't know
Don't know	0	Pubis:Ischi	3	Don't know	0	Left	0	Don't know
Don't know	0	Pubis:Ilium	2	Left	0	Left	0	FALSE
Don't know	0	Pubis:Ischi	3	Don't know	0	Right	1	TRUE
Don't know	0	Acetabulun	2		0	Right	1	
Don't know	0	Pubis:Ilium	2	Don't know	0	Left	0	TRUE
Ischium	1	Pubis	1	Right	1	Right	1	TRUE
Don't know	0	Ilium:Pubis	2	Don't know	0	Left	0	Don't know
	0	Pubis:Ischi	2	Right	1	Right	1	Don't know
Don't know	0	Acetabulun	2	Left	0	Left	0	TRUE
Don't know	0	Ilium:Aceta	2	Don't know	0	Right	1	Don't know
Don't know	0	Pubis	1	Don't know	0	Left	0	Don't know
Don't know	0	Don't know	0	Right	1	Left	0	Don't know
Don't know	0	Ilium:Ischiu	3	Left	0	Right	1	Don't know
Don't know	0	Ischium:Iliu	3	Don't know	0	Right	1	Don't know
Don't know	0	Pubis:Ilium	3	Don't know	0	Left	0	FALSE
Don't know	0	Don't know	0	Don't know	0	Don't know	0	Don't know
Don't know	0	Ischium:Iliu	3	Left	0	Left	0	TRUE
Don't know	0	Pubis:Ilium	3	Left	0	Don't know	0	Don't know
Ischium:Pu	3	Ischium:Pu	3	Right	1	Don't know	0	Don't know
Ilium:Ischiu	2	Trochanter	2	Left	0	Left	0	TRUE
Don't know	0	Ilium:Aceta	1	Left	0	Left	0	FALSE
Don't know	0	Pubis	1	Left	0	Left	0	Don't know

Don't know	0	Pubis:Ilium	3	Don't know	0	Right	1	Don't know
Don't know	0	Ilium:Ischiu	3	Left	0	Right	1	FALSE
Don't know	0	Pubis:Ilium	3	Left	0	Left	0	TRUE
Don't know	0	Ischium	1	Right	1	Right	1	TRUE
Don't know	0	Ischium:Iliu	3	Left	0	Right	1	Don't know
Don't know	0	Ilium:Pubis	3	Left	0	Right	1	Don't know
Don't know	0	Pubis:Ilium	3	Right	1	Right	1	Don't know
Don't know	0	Ilium:Ischiu	3	Right	1	Right	1	Don't know
Don't know	0	Ilium:Ischiu	3	Don't know	0	Left	0	Don't know
Don't know	0	Pubis:Ilium	3	Don't know	0	Left	0	Don't know
Don't know	0	Ilium:Pubis	3	Left	0	Right	1	TRUE
Pubis	1	Ilium:Pubis	3	Left	0	Left	0	FALSE
	0	Ischium:Pu	3	Left	0	Right	1	TRUE
Pubis	1	Ilium:Pubis	3	Left	0	Right	1	TRUE
Don't know	0	Ilium:Pubis	3		0	Left	0	FALSE
Don't know	0	Ischium:Iliu	2	Left	0	Left	0	Don't know
	0	Pubis:Ilium	3	Right	1	Left	0	Don't know
Ilium:Aceta	1	Pubis:Ischi	3	Right	1	Right	1	TRUE
Don't know	0	Ilium:Ischiu	3	Left	0	Right	1	FALSE
Don't know	0	Pubis:Ischi	3	Left	0	Right	1	Don't know
Don't know	0	Ilium:Ischiu	3	Don't know	0	Right	1	Don't know
Pubis:Ilium	3	Ischium:Iliu	3	Left	0	Right	1	Don't know
Don't know	0	Ilium:Pubis	3	Left	0	Left	0	TRUE
Don't know	0	Ilium:Pubis	3	Right	1	Right	1	Don't know
Pubis:Ilium	2	Pubis:Ilium	3	Right	1	Left	0	TRUE
Don't know	0	Ilium:Pubis	2	Don't know	0	Right	1	Don't know
Don't know	0	Ilium:Ischiu	3	Don't know	0	Right	1	Don't know
Don't know	0	Ischium:Iliu	3	Left	0	Left	0	Don't know
Don't know	0	Ischium:Iliu	3	Don't know	0	Right	1	Don't know
Ilium:Pubis	3	Pubis:Ilium	3	Left	0	Right	1	TRUE
Don't know	0	Pubis:Ilium	3	Don't know	0	Right	1	Don't know
Ilium:Pubis	3	Pubis:Ilium	3	Left	0	Right	1	FALSE
Pubis:Ischi	3	Ischium:Pu	3	Left	0	Left	0	TRUE
Ilium:Pubis	3	Ischium:Pu	3	Left	0	Left	0	FALSE
Pubis:Ilium	3	Ilium:Pubis	3	Right	1	Right	1	TRUE
Ilium:Ischiu	3	Pubis:Ilium	3	Right	1	Right	1	TRUE
Pubis:Ischi	3	Ilium:Pubis	3	Right	1	Right	1	TRUE
Pubis:Ischi	3	Ilium:Ischiu	3	Right	1	Right	1	TRUE
Ilium:Ischiu	3	Pubis:Ilium	3	Left	0	Right	1	TRUE
Pubis:Ischi	3	Pubis:Ilium	3	Right	1	Right	1	FALSE
Ischium:Iliu	3	Ischium:Iliu	3	Right	1	Right	1	TRUE
Don't know	0	Pubis:Ilium	3	Don't know	0	Left	0	TRUE
Ischium:Iliu	3	Ilium:Ischiu	2	Right	1	Right	1	FALSE
Don't know	0	Ilium:Pubis	3	Right	1	Right	1	Don't know
Ilium:Ischiu	3	Pubis:Ischi	3	Right	1	Right	1	FALSE
Ischium:Iliu	3	Pubis:Ilium	3	Right	1	Right	1	FALSE
Pubis:Ilium	3	Ilium:Ischiu	3	Left	0	Right	1	FALSE
Don't know	0	Ischium:Iliu	3	Don't know	0	Left	0	FALSE
Ilium:Pubis	3	Pubis:Ilium	3	Right	1	Right	1	FALSE
Pubis:Ilium	3	Ischium:Iliu	3	Right	1	Right	1	TRUE
Ilium:Pubis	3	Ischium:Pu	3	Right	1	Right	1	FALSE

Pubis:Ischi	3	Pubis:Ilium	3	Right	1	Right	1	TRUE
Pubis:Ischi	3	Ischium:Pu	3	Right	1	Right	1	FALSE
Acetabulun	2	Ischium:Iliu	3	Right	1	Right	1	Don't know
Ischium:Iliu	3	Pubis:Ischi	3	Right	1	Right	1	FALSE
Ischium:Iliu	2	Ischium:Pu	3	Right	1	Right	1	FALSE
Ischium:Pu	3	Pubis:Ischi	3	Right	1	Left	0	Don't know
Pubis:Ilium	3	Ischium:Pu	3	Right	1	Right	1	TRUE
Pubis:Ilium	3	Ischium:Pu	3	Left	0	Right	1	FALSE
Ilium:Pubis	3	Ischium:Pu	3	Right	1	Right	1	TRUE
Pubis:Ilium	3	Ischium:Pu	3	Right	1	Right	1	TRUE
Pubis:Ilium	3	Pubis:Ischi	3	Right	1	Right	1	TRUE
Ilium:Ischiu	3	Ischium:Pu	3	Right	1	Right	1	FALSE
Ilium:Pubis	3	Pubis:Ilium	3	Right	1	Right	1	FALSE
Ilium:Ischiu	3	Ischium:Pu	3	Right	1	Right	1	FALSE
Ischium:Pu	3	Pubis:Ilium	3	Right	1	Right	1	FALSE
Ilium:Pubis	3	Ilium	1	Right	1	Right	1	TRUE
Don't know	0	Ilium:Pubis	3	Don't know	0	Right	1	Don't know
Don't know	0	Ilium:Ischiu	2	Don't know	0	Don't know	0	Don't know
Don't know	0	Don't know	0	Don't know	0	Left	0	Don't know
Ischium:Pu	2	Ilium:Ischiu	2	Right	1	Right	1	TRUE
Pubis	1	Ilium:Ischiu	3	Right	1	Left	0	FALSE
Ischium:Iliu	2	Ilium:Pubis	3	Left	0	Right	1	TRUE

: The right and nnominates form part of the axial			Question 3: A synovial joint can be seen above.				Question 4: The fusing the iliac crest suggests	
Score 1	**Answer 2**	**Score 2**	**Answer 1**	**Score 1**	**Answer 2**	**Score 2**	**Answer 1**	**Score 1**
0	TRUE	0	Don't know	0	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	It is juvenile	1
1	TRUE	0	Don't know	0	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	It is juvenile	1
0	FALSE	1	Don't know	0	Don't know	0	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	Don't know	0
0			TRUE	1			It is adult	0
0	TRUE	0	TRUE	1	TRUE	1	It is juvenile	1
0	TRUE	0	Don't know	0	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	Don't know	0
0	TRUE	0	Don't know	0	TRUE	1	Don't know	0
0	TRUE	0	FALSE	0	TRUE	1	Don't know	0
0	TRUE	0	TRUE	1	FALSE	0	It is juvenile	1
0	FALSE	1	TRUE	1	TRUE	1	It is adult	0
0	TRUE	0	Don't know	0	Don't know	0	It is adult	0
0	TRUE	0	TRUE	1	TRUE	1	Don't know	0
0	TRUE	0	TRUE	1	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	Don't know	0
0	TRUE	0	TRUE	1	TRUE	1	Don't know	0
0	FALSE	1	Don't know	0	TRUE	1	Don't know	0
0	TRUE	0	Don't know	0	TRUE	1	Don't know	0
0	Don't know	0	TRUE	1	TRUE	1	Don't know	0
0	Don't know	0	Don't know	0	TRUE	1	It is juvenile	1
0	TRUE	0	FALSE	0	FALSE	0	Don't know	0
1	TRUE	0	TRUE	1	TRUE	1	It is adult	0
0	FALSE	1	TRUE	1	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	It is juvenile	1
0	TRUE	0	TRUE	1	TRUE	1	It is juvenile	1
0	TRUE	0	TRUE	1	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	It is adult	0
0	TRUE	0	Don't know	0	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	It is juvenile	1
0	Don't know	0	Don't know	0	FALSE	0	It is adult	0
0	TRUE	0	Don't know	0	Don't know	0	Don't know	0
1	FALSE	1	Don't know	0	TRUE	1	It is juvenile	1
0	Don't know	0	Don't know	0	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	Don't know	0	It is adult	0
0	FALSE	1	TRUE	1	Don't know	0	Don't know	0
0	TRUE	0	FALSE	0	Don't know	0	It is juvenile	1
0	TRUE	0	TRUE	1	TRUE	1	It is juvenile	1
1	FALSE	1	TRUE	1	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	Don't know	0

0	Don't know	0	Don't know	0	TRUE	1	Don't know	0
1	FALSE	1	Don't know	0	TRUE	1	It is juvenile	1
0	FALSE	1	TRUE	1	TRUE	1	It is juvenile	1
0	TRUE	0	TRUE	1	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	It is adult	0
0	FALSE	1	TRUE	1	TRUE	1	It is adult	0
0	FALSE	1	TRUE	1	FALSE	0	It is adult	0
0	FALSE	1	Don't know	0	TRUE	1	Don't know	0
0	FALSE	1	Don't know	0	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	It is juvenile	1
1	FALSE	1	FALSE	0	TRUE	1	It is juvenile	1
0	FALSE	1	FALSE	0	TRUE	1	Don't know	0
0	TRUE	0	TRUE	1	TRUE	1	Don't know	0
1	FALSE	1		0	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	Don't know	0
0	TRUE	0	TRUE	1	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	FALSE	0		0
1	FALSE	1	TRUE	1	TRUE	1	It is adult	0
0	FALSE	1	TRUE	1	TRUE	1	It is adult	0
0	TRUE	0	TRUE	1	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	Don't know	0
0	TRUE	0	TRUE	1	FALSE	0	It is adult	0
0	FALSE	1	FALSE	0	TRUE	1	It is adult	0
0	FALSE	1	TRUE	1	TRUE	1	It is adult	0
0	FALSE	1	Don't know	0	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	Don't know	0
0	TRUE	0	Don't know	0	TRUE	1	Don't know	0
0	FALSE	1	TRUE	1	TRUE	1	It is juvenile	1
0	TRUE	0	TRUE	1	TRUE	1	It is juvenile	1
1	TRUE	0	TRUE	1	TRUE	1	It is juvenile	1
0	TRUE	0	FALSE	0	TRUE	1	It is juvenile	1
1	FALSE	1	TRUE	1	TRUE	1	It is juvenile	1
0	FALSE	1	TRUE	1	TRUE	1	It is adult	0
0	FALSE	1	TRUE	1	TRUE	1	It is juvenile	1
0	TRUE	0	TRUE	1	TRUE	1	Don't know	0
0	TRUE	0	TRUE	1	TRUE	1	It is juvenile	1
0	FALSE	1	TRUE	1	TRUE	1	It is juvenile	1
1	TRUE	0	TRUE	1	TRUE	1	It is juvenile	1
0	TRUE	0	TRUE	1	TRUE	1	It is adult	0
0	FALSE	1	TRUE	1	TRUE	1	It is juvenile	1
1	FALSE	1	TRUE	1	TRUE	1	It is juvenile	1
0	FALSE	1	TRUE	1	TRUE	1	Don't know	0
1	FALSE	1	TRUE	1	TRUE	1	It is juvenile	1
1	TRUE	0	TRUE	1	TRUE	1	It is adult	0
1	TRUE	0	TRUE	1	TRUE	1	It is juvenile	1
1	FALSE	1	TRUE	1	TRUE	1	It is juvenile	1
1	TRUE	0	TRUE	1	TRUE	1	It is juvenile	1
0	TRUE	0	TRUE	1	TRUE	1	It is adult	0
1	FALSE	1	TRUE	1	TRUE	1	Don't know	0

0	TRUE	0	TRUE	1	TRUE	1	It is juvenil	1
1	FALSE	1	TRUE	1	TRUE	1	It is juvenil	1
0	TRUE	0	TRUE	1	TRUE	1	It is juvenil	1
1	FALSE	1	TRUE	1	TRUE	1	It is juvenil	1
1	FALSE	1	TRUE	1	TRUE	1	It is juvenil	1
0	FALSE	1	TRUE	1	TRUE	1	It is juvenil	1
0	FALSE	1	TRUE	1	TRUE	1	It is juvenil	1
1	FALSE	1	TRUE	1	TRUE	1	It is juvenil	1
0	TRUE	0	TRUE	1	TRUE	1	It is juvenil	1
0	FALSE	1	TRUE	1	TRUE	1	It is juvenil	1
0	FALSE	1	TRUE	1	TRUE	1	It is juvenil	1
1	FALSE	1	TRUE	1	TRUE	1	It is juvenil	1
1	FALSE	1	TRUE	1	TRUE	1	It is juvenil	1
1	TRUE	0	TRUE	1	TRUE	1	It is juvenil	1
1	FALSE	1	TRUE	1	TRUE	1	It is juvenil	1
0	FALSE	1	TRUE	1	TRUE	1	It is juvenil	1
0	FALSE	1	Don't know	0	Don't know	0	Don't know	0
0	TRUE	0	TRUE	1	FALSE	0	Don't know	0
0	FALSE	1	Don't know	0	TRUE	1	Don't know	0
0	TRUE	0	TRUE	1	TRUE	1	It is adult	0
1	FALSE	1	TRUE	1	TRUE	1	Don't know	0
0	TRUE	0	TRUE	1	TRUE	1	It is juvenil	1

epiphysis present on ...		Question 5: The most superior portion of the pelvis is the iliac crest.				Question 6: Which bone(s) contrib acetabulum?		
Answer 2	**Score 2**	**Answer 1**	**Score 1**	**Answer 2**	**Score 2**	**Answer 1**	**Score 1**	**Answer 2**
It is adult	0	Don't know	0	FALSE	0	Don't know	0	Sacrum:Isc
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Don't know
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Ilium:Pubis
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Ischium:Iliu
Don't know	0	Don't know	0	FALSE	0	Don't know	0	Don't know
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Don't know
		Don't know	0			Don't know	0	
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Don't know
It is adult	0	TRUE	1	Don't know	0	Don't know	0	Pubis:Ischi
It is adult	0	Don't know	0	FALSE	0	Don't know	0	Don't know
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Don't know
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Don't know
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Ischium:Iliu
It is adult	0	FALSE	0	TRUE	1	Don't know	0	Pubis:Ilium
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Ilium:Ischiu
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Ischium:Iliu
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Don't know
Don't know	0	Don't know	0	Don't know	0	Don't know	0	Don't know
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Pubis:Ischi
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Ischium
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Don't know
Don't know	0	Don't know	0	TRUE	1	Don't know	0	Don't know
Don't know	0	Don't know	0		0	Don't know	0	
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Ilium:Ischiu
It is adult	0	Don't know	0	FALSE	0	Don't know	0	Ischium:Sa
Don't know	0	Don't know	0	TRUE	1	Don't know	0	Pubis:Ilium
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Ischium:Sa
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Don't know
It is juvenile	1	TRUE	1	TRUE	1	Pubis	1	Ischium
It is juvenile	1	Don't know	0	FALSE	0	Don't know	0	Pubis:Ilium
It is adult	0	Don't know	0	Don't know	0	Don't know	0	Don't know
It is juvenile	1	Don't know	0	Don't know	0	Don't know	0	Ischium:Iliu
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Ischium:Sa
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Don't know
It is juvenile	1	TRUE	1	TRUE	1	Don't know	0	Don't know
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Pubis:Ilium
It is adult	0	Don't know	0	Don't know	0	Don't know	0	Ilium:Ischiu
It is juvenile	1	Don't know	0	FALSE	0	Don't know	0	Ilium:Pubis
It is juvenile	1	Don't know	0	FALSE	0	Don't know	0	Don't know
It is juvenile	1	TRUE	1	TRUE	1	Sacrum:Isc	1	Pubis:Ischi
Don't know	0	Don't know	0	TRUE	1	Don't know	0	Don't know
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Ilium:Pubis
It is adult	0	TRUE	1	TRUE	1	Don't know	0	Ischium:Pu
	0	Don't know	0		0	Don't know	0	
It is adult	0	Don't know	0	Don't know	0	Don't know	0	Ilium:Pubis

Don't know	0	Don't know	0		0	Don't know	0	
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Ilium:Ischiu
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Pubis:Ilium
It is adult	0	FALSE	0	TRUE	1	Don't know	0	Ischium:Pu
Don't know	0	Don't know	0	TRUE	1	Don't know	0	Don't know
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Ischium:Pu
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Ischium:Pu
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Ischium:Iliu
It is juvenile	1	Don't know	0	Don't know	0	Don't know	0	Ilium:Pubis
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Pubis:Ilium
It is juvenile	1	TRUE	1	TRUE	1	Don't know	0	Ischium:Pu
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Ilium:Ischiu
Don't know	0	Don't know	0	TRUE	1	Don't know	0	Ischium:Iliu
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Ilium:Ischiu
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Pubis:Ischi
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Don't know
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Pubis:Ilium
It is juvenile	1		0	TRUE	1		0	Ilium:Pubis
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Ischium:Pu
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Ischium:Iliu
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Pubis:Ischi
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Ilium:Ischiu
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Pubis:Ilium
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Ischium:Pu
It is adult	0	TRUE	1	TRUE	1	Ilium:Femu	2	Ischium:Iliu
Don't know	0	Don't know	0	TRUE	1	Don't know	0	Sacrum:Iliu
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Ilium:Ischiu
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Ilium:Ischiu
It is adult	0	Don't know	0		0	Don't know	0	Pubis:Ischi
It is juvenile	1	TRUE	1	TRUE	1	Sacrum:Pu	2	Ischium:Iliu
It is adult	0	TRUE	1	TRUE	1	Don't know	0	Ischium:Pu
It is juvenile	1	TRUE	1	TRUE	1	Pubis:Ischi	3	Ischium:Pu
It is adult	0	TRUE	1	TRUE	1	Don't know	0	Pubis:Ilium
It is juvenile	1	TRUE	1	TRUE	1	Don't know	0	Ischium:Iliu
It is juvenile	1	TRUE	1	TRUE	1	Ischium:Iliu	3	Ilium:Ischiu
It is adult	0	TRUE	1	TRUE	1	Pubis:Ilium	3	Ilium:Ischiu
It is juvenile	1	TRUE	1	TRUE	1	Ilium:Pubis	3	Ischium:Pu
It is juvenile	1	TRUE	1	TRUE	1	Ilium:Ischiu	3	Pubis:Ilium
It is juvenile	1	TRUE	1	TRUE	1	Ischium:Iliu	3	Ischium:Pu
It is juvenile	1	TRUE	1	TRUE	1	Ilium:Ischiu	3	Ilium:Pubis
It is juvenile	1	TRUE	1	TRUE	1	Pubis:Ilium	3	Ischium:Pu
It is adult	0	FALSE	0	TRUE	1	Don't know	0	Pubis:Ilium
It is adult	0	TRUE	1	TRUE	1	Pubis:Ischi	3	Ilium:Pubis
It is juvenile	1	TRUE	1	TRUE	1	Don't know	0	Ilium:Pubis
It is juvenile	1	TRUE	1	TRUE	1	Pubis:Ischi	3	Pubis:Ischi
It is juvenile	1	TRUE	1	TRUE	1	Pubis:Ischi	3	Ischium:Iliu
It is juvenile	1	TRUE	1	TRUE	1	Ilium:Pubis	3	Ilium:Ischiu
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Ilium:Ischiu
It is juvenile	1	TRUE	1	TRUE	1	Don't know	0	Pubis:Ischi
It is adult	0	TRUE	1	TRUE	1	Ischium:Iliu	3	Pubis:Ilium
It is juvenile	1		0	TRUE	1	Pubis:Ischi	3	Ischium:Iliu

It is juvenile	1	TRUE	1	TRUE	1	Ischium:Iliu	3	Ilium:Ischiu
Don't know	0	TRUE	1	TRUE	1	Ilium:Ischiu	3	Ilium:Pubis
It is juvenile	1	TRUE	1	TRUE	1	Ischium:Pu	3	Ilium:Ischiu
It is juvenile	1	TRUE	1	TRUE	1	Ilium:Ischiu	3	Pubis:Ilium
It is juvenile	1	FALSE	0	TRUE	1	Ischium	1	Pubis:Ischi
It is juvenile	1	TRUE	1	TRUE	1	Ischium:Pu	3	Pubis:Ischi
It is juvenile	1	TRUE	1	TRUE	1	Ilium:Ischiu	3	Pubis:Ischi
It is juvenile	1	TRUE	1	TRUE	1	Pubis:Ischi	3	Ischium:Pu
It is juvenile	1	TRUE	1	TRUE	1	Ischium:Iliu	2	Ischium:Pu
It is juvenile	1	TRUE	1	TRUE	1	Pubis:Ischi	3	Ilium:Pubis
It is juvenile	1	TRUE	1	TRUE	1	Ilium:Ischiu	2	Ischium:Pu
It is juvenile	1	TRUE	1	FALSE	0	Pubis:Ischi	3	Pubis:Ischi
It is juvenile	1	TRUE	1	TRUE	1	Ischium:Iliu	3	Pubis:Ilium
It is juvenile	1	TRUE	1	TRUE	1	Ilium:Pubis	3	Ischium:Iliu
It is juvenile	1	TRUE	1	TRUE	1	Ischium:Pu	3	Pubis:Ischi
It is juvenile	1	TRUE	1	TRUE	1	Ischium:Pu	3	Pubis:Ilium
It is adult	0	Don't know	0	Don't know	0	Don't know	0	Femur
It is adult	0	Don't know	0	TRUE	1	Don't know	0	Ilium:Ischiu
It is juvenile	1	Don't know	0	TRUE	1	Don't know	0	Pubis:Ilium
It is juvenile	1	FALSE	0	TRUE	1	Femur	0	Ilium:Ischiu
It is juvenile	1	TRUE	1	TRUE	1	Don't know	0	Pubis:Ischi
It is juvenile	1	TRUE	1	FALSE	0	Ischium:Iliu	2	Pubis:Ischi

ute to the	Question 7: The inguinal ligament attaches to which bony elements?				Question 8: Assign a sex to each of the following pelves by dragging the label over the appropriate pelvis (If you don't know please leave unanswered)			
Score 2	**Answer 1**	**Score 1**	**Answer 2**	**Score 2**	**Answer 1**	**Score 1**	**Answer 2**	**Score 2**
1	Don't know	0	Ischial spin	0	173,462:17	2	173,500:17	2
0	Don't know	0	Don't know	0	173,383:17	2	138,628:17	2
3	Don't know	0	Pubic tube	1	173,428:17	2	173,478:17	2
2	Don't know	0	Don't know	0	173,435:17	2	138,385:16	2
0	Don't know	0	Don't know	0	173,374:17	2	173,495:17	2
0	Don't know	0	Don't know	0	:138,18	0	173,480:17	2
	Don't know	0			173,421:17	2		
0	Don't know	0	Don't know	0	173,386:17	2	146,525:13	2
3	Don't know	0	Don't know	0	173,423:17	2	173,664:17	2
0	Don't know	0	Don't know	0	138,385:17	2	173,560:17	2
0	Don't know	0	Don't know	0		0	173,482:17	2
0	Don't know	0	Don't know	0		0	173,642:17	2
2	Don't know	0	Don't know	0		0	173,369:17	2
3		0	Don't know	0	138,397:17	2	:173,306	0
3	Don't know	0	Don't know	0		0	173,533:17	2
3	Don't know	0	Don't know	0	173,456:17	2	173,518:17	2
0	Don't know	0	Don't know	0	173,380:17	2	173,529:17	2
0		0	Don't know	0	:147,18	0	173,507:17	2
3		0	Don't know	0	138,393:17	2	173,546:17	2
1	Don't know	0	Anterior inf	1		0	173,631:17	2
0	Don't know	0	Ischial spin	0		0	170,612:17	2
0	Don't know	0	Don't know	0	138,370:13	2	173,601:17	2
0	Don't know	0		0	141,653:17	2		0
3	Don't know	0	Don't know	0	173,488:17	2	173,518:17	2
1	Don't know	0	Anterior inf	0	173,517:17	2	173,500:17	2
3	Don't know	0	Anterior su	2	173,383:17	2	173,430:17	2
2		0	Anterior su	1	:142,386	0	:173,260	0
0	Don't know	0	Don't know	0	138,32:142	0	138,564:17	2
1	Ischial tube	0	Anterior inf	0	173,417:17	2	:173,237	0
3	Don't know	0	Pubic tube	1	173,527:17	2	173,496:17	2
0	Don't know	0	Don't know	0		0	173,588:17	2
3	Don't know	0	Ischial spin	0	173,402:17	2	173,378:17	2
1	Don't know	0	Don't know	0	173,501:17	2	173,572:17	2
0	Don't know	0	Don't know	0	138,504:17	2	173,562:17	2
0	Don't know	0	Anterior inf	0	173,529:17	2	173,495:17	2
3	Don't know	0	Don't know	0	173,478:17	2	173,518:17	2
3	Don't know	0	Don't know	0	173,620:17	2	173,508:17	2
3	Don't know	0	Don't know	0	173,483:17	2	173,494:17	2
0	Don't know	0	Don't know	0		0	173,515:17	2
3	Ischial tube	0	Don't know	0	173,169:17	0	173,440:17	2
0	Don't know	0	Don't know	0	173,664:17	2	173,612:17	2
2	Don't know	0	Anterior su	2		0	173,484:17	2
3	Anterior su	1	Don't know	0	173,617:17	2	173,503:17	2
0	Don't know	0		0	138,458:17	2		0
3	Don't know	0	Don't know	0	173,574:17	2	173,617:17	2

0	Don't know	0		0	173,299:17	0		0
3	Don't know	0	Anterior su	2	173,479:17	2	173,586:17	2
3	Don't know	0	Pubic tube	1	173,624:17	2	173,444:17	2
2	Don't know	0	Don't know	0	138,625:17	2	173,538:17	2
0	Don't know	0	Anterior inf	0	173,599:17	2	173,629:17	2
3	Don't know	0	Anterior su	1	173,510:17	2	173,397:17	2
3	Don't know	0	Anterior su	2	173,521:17	2	173,510:17	2
3	Don't know	0	Anterior su	2	NaN,NaN:N	0	173,517:17	2
3	Don't know	0	Anterior su	2		0	:173,310	0
3	Don't know	0	Anterior su	2	173,656:17	2	173,502:17	2
3	Don't know	0	Anterior su	2	138,664:17	2	173,593:17	2
3	Don't know	0	Anterior su	2	173,642:17	2	173,506:17	2
3	Don't know	0		0	173,488:17	2		0
3	Don't know	0	Anterior su	1	173,498:17	2	173,485:17	2
2	Don't know	0	Anterior su	2		0	173,537:17	2
0	Don't know	0	Anterior inf	0	173,522:17	2	173,520:17	2
3	Don't know	0	Anterior su	2		0	173,638:17	2
3		0	Anterior su	2		0	:173,317	0
3	Don't know	0	Anterior su	2	173,560:17	2	173,537:17	2
3	Don't know	0	Anterior su	2	:NaN,NaN	0	173,510:17	2
3	Don't know	0	Anterior su	2	173,498:17	2	173,569:17	2
3	Don't know	0	Anterior su	2	NaN,NaN:N	0	173,606:17	2
3	Don't know	0	Anterior su	2	173,538:17	2	173,508:17	2
3	Don't know	0	Anterior su	1	173,532:17	2	173,514:17	2
3	Anterior su	2	Anterior su	2	173,515:17	2	173,508:17	2
2	Don't know	0	Anterior su	2	173,513:17	2	173,512:17	2
3	Don't know	0	Anterior su	2	173,295:17	0	138,570:17	2
3	Don't know	0	Anterior su	2	173,494:17	2	173,513:17	2
3	Don't know	0	Anterior su	2		0	173,614:17	2
3	Don't know	0	Anterior su	2	173,595:17	2	173,516:17	2
3	Don't know	0	Anterior su	2	NaN,NaN:N	0	173,535:17	2
3	Anterior su	2	Anterior su	2	173,515:17	2	173,506:17	2
3	Anterior su	2	Pubic tube	1	:173,314	0	173,556:17	2
3	Anterior su	2	Anterior su	2	173,504:17	2	173,469:17	2
3	Anterior su	2	Anterior su	2	NaN,NaN:N	0	:138,327	0
3	Anterior su	1	Anterior su	1	138,368:17	2	:138,315	0
3	Anterior su	2	Anterior su	2	173,501:17	2	173,506:17	2
3	Anterior su	2	Anterior su	2	173,454:17	2	:173,317	0
3	Anterior su	2	Anterior su	2	173,501:17	2	173,512:17	2
3	Anterior su	2	Anterior su	2	173,660:17	2	173,544:17	2
3	Anterior su	2	Anterior su	2	:138,333	0	173,531:17	2
3	Anterior su	2	Anterior su	2	173,606:17	2	173,494:17	2
3	Don't know	0	Anterior su	2	173,507:17	2	173,536:17	2
3	Don't know	0	Anterior su	2	173,508:17	2	173,510:17	2
3	Anterior su	2	Pubic tube	1	173,505:17	2	173,558:17	2
3	Anterior su	2	Anterior su	2	173,511:17	2	173,523:17	2
3	Anterior su	2	Anterior su	1	173,504:17	2	173,548:17	2
3	Anterior su	1	Pubic tube	1	173,376:17	2	173,529:17	2
3	Don't know	0	Anterior su	2	173,503:17	2	173,515:17	2
3	Anterior su	2	Anterior inf	1	173,515:17	2	165,588:13	2
3		0	Pubic tube	1	173,514:17	2	173,511:17	2

3	Anterior su	2	Anterior su	2	173,499:17	2	173,512:17	2
3	Anterior su	2	Anterior su	2	173,493:17	2	173,513:17	2
3	Anterior su	2	Anterior su	2	173,445:17	2	173,462:17	2
3	Anterior su	2	Anterior su	2	173,512:17	2	173,525:17	2
3	Don't know	0	Anterior su	2	173,516:17	2	173,516:17	2
3	Anterior su	1	Don't know	0	173,524:17	2	173,510:17	2
3	Ischial tube	0	Anterior su	2	173,508:17	2	173,502:17	2
3	Anterior inf	0	Anterior su	2	173,649:17	2	:173,320	0
3	Ischial spin	0	Ischial tube	1	173,509:17	2	173,506:17	2
3	Anterior su	1	Pubic tuber	1	173,470:17	2	173,499:17	2
3	Anterior su	2	Anterior su	2	173,509:17	2	173,522:17	2
3	Anterior su	2	Anterior su	2	173,511:17	2	173,530:17	2
3	Anterior su	2	Anterior su	2	173,583:17	2	173,487:17	2
3	Anterior su	2	Anterior su	2	173,516:17	2	173,499:17	2
3	Anterior su	2	Anterior su	2	173,494:17	2	173,545:17	2
3	Pubic tuber	1	Anterior su	2	NaN,NaN:N	0	173,535:17	2
0	Don't know	0	Don't know	0		0	173,396:17	2
2	Don't know	0	Don't know	0	138,392:13	2	173,493:17	2
3	Don't know	0	Don't know	0		0	173,469:17	2
3	Don't know	0	Anterior inf	1	173,402:17	2	173,497:17	2
3	Don't know	0	Don't know	0	138,385:13	2	173,663:17	2
3	Don't know	0	Anterior inf	0	173,664:17	2	173,540:16	2

Question 9: Drag these labels to the appropriate bony element (If you don't know please leave unanswered)				Question 10: Label the following structures (If you don't know please leave unanswered)			
Answer 1	**Score 1**	**Answer 2**	**Score 2**	**Answer 1**	**Score 1**	**Answer 2**	**Score 2**
	0	130,433:59	0		0	143,52:515	0
:175,35:25(	0	152,97:591	1	621,418:15	4	608,422:14	4
:66,42:170,	0	115,101:12	3	208,11:515	0	621,425:15	4
	0	105,107:12	3		0	615,421:15	4
:230,9:133,	0	106,101:11	3	:336,9:69,1	0	130,423:51	0
::59,8	0	121,102:12	3		0		0
	0			:515,425::	0		
:73,39:188,	0	126,109:13	3	235,9:481,(	0	602,429:15	4
113,86:146	3	136,95:150	3	288,9:487,(	1		0
::59,8	0		0		0		0
	0	123,96:112	3		0		0
	0	127,107:13	3		0	620,431:15	4
	0	128,438:59	0		0	598,420:15	4
	0	107,101:12	3		0	611,421:51	1
	0	106,111:12	3		0	619,431::6	2
	0	105,99:139	3		0	621,426:15	2
	0	127,99:130	3		0	617,423:14	4
	0	127,101:11	3		0	621,422::6	2
59,8:154,2	0	114,429:11	1	:342,11:59	0	145,52:174	2
	0	116,434:11	1		0	621,424:51	1
	0		0		0		0
:171,8:59,3	0	123,435:12	1	83,164:370	0	609,420:16	2
:151,43:26	0		0	620,423:25	1		0
	0		0		0		0
:77,39:204,	0	121,433:59	0	142,425:51	2	616,423:15	4
106,23:243	0	116,99:113	3	:136,267:5(	0	615,425:51	2
	0		0		0	605,422:16	2
	0	106,99:120	3		0	621,422:14	2
116,109:12	3	579,367:11	0	600,422:51	1	603,425:15	2
	0	122,102:12	3		0	607,421:15	2
	0	111,102:13	3		0	621,422:19	2
171,10:591	0	121,105:59	1	621,426:15	4	605,421:15	4
	0	149,107:14	3		0	152,425:51	2
	0	::581,369	1	::137,421:	0	592,430:15	4
125,100:13	3	132,105:13	3	130,424:51	2	601,421:14	4
:339,8:222,	0		0	223,9:515,(	0	600,423:15	4
	0	125,103:13	3		0	621,423:15	4
	0	115,104:11	3		0	616,422:24	2
	0	116,92:591	1		0		0
120,100:58	1	133,107:12	3	133,52:515	0	621,422:15	4
	0	116,105:11	3	:515,423:1(	0		0
	0	125,105:11	3	592,426:15	4	621,423:15	2
117,435:12	1	128,102:11	3	611,425:15	4	617,424:16	4
	0		0		0		0
	0	123,104:12	3		0	612,416:::	1

	0		0		0		0
119,107:11	3	116,107:13	3	596,423:15	4	604,421:15	4
::427,519	0	111,104:12	3	126,429:51	0	600,424:16	4
	0	108,102:12	3	596,428:15	2	599,422:14	4
::119,107	0	120,99:116	3	87,454:::	0	617,420:15	2
::591,368	1	125,101:12	3		0	601,423:15	4
	0	115,103:12	3		0	621,421:15	4
NaN,NaN:N	0	115,105:11	3	NaN,NaN:N	0	621,424:15	4
	0	133,104:13	3		0	595,426:51	2
	0	128,111:12	3		0	610,424:14	4
91,102:137	3	109,118:14	3	603,425:15	4	595,421:51	2
::125,102	0	111,103:10	3	615,421:51	2	621,426:15	4
	0		0		0		0
	0	124,102:11	3		0	621,425:15	4
	0	118,99:117	3		0	621,420:15	4
	0	123,100:12	3		0	598,422:15	4
	0	114,109:12	3		0		0
	0	147,101:11	3		0	617,421:16	4
::123,104	0	117,108:11	3	141,54:286	1	615,424:15	4
	0	118,108:11	3		0	594,422:15	4
	0	128,94:132	3		0	621,425:15	4
	0	116,102:12	3	::NaN,NaN	0	605,423:15	4
	0	115,103:12	3		0	606,423:15	4
114,432:11	1	121,103:11	3	613,426:::	1	616,426:16	4
117,97:134	3	120,102:12	3	606,417:16	2	609,422:51	2
	0	123,99:127	3		0	621,414:15	4
	0	102,108:14	3		0	599,418:16	4
	0	113,97:124	3		0	607,422:15	4
	0	106,99:135	3		0	621,424:13	4
115,98:130	3	131,103:12	3	616,422:13	4	608,427:16	4
:NaN,NaN:	0	117,101:12	3	NaN,NaN:N	0	604,425:15	4
125,105:58	1	126,96:128	3	618,420:17	4	621,419:15	4
110,109:11	3	115,106:12	3	615,420:51	1	621,423:15	4
113,102:11	3	116,103:12	3	614,425:15	4	617,423:15	4
NaN,NaN:N	0	146,107:13	3	NaN,NaN:N	0	605,422:15	4
117,101:12	3	118,101:12	3	610,423:15	4	577,420:15	4
111,104:12	3	127,101:12	3	614,421:51	2	611,423:15	4
120,111:11	3	123,105:11	3	615,426:13	4	609,421:15	4
134,103:10	3	130,102:12	3	609,422:51	2	621,421:15	4
115,101:12	3	119,105:11	3	614,423:15	4	621,423:15	4
119,102:12	3	114,103:12	3	621,426:15	4	614,422:15	4
130,95:118	3	115,103:12	3	602,420:15	4	608,421:15	4
108,98:121	3	110,98:104	3	592,425:15	4	621,428:15	4
136,107:11	3	118,104:12	3		0	615,424:15	4
123,99:143	3	111,103:12	3	607,427:15	4	621,421:15	4
121,104:11	3	117,100:12	3	616,423:15	4	616,427:15	4
129,105:59	1	124,106:11	3	621,426:15	4	619,422:15	4
::591,372	1	130,98:125	3	616,422:51	2	604,415:15	4
120,106:11	3	113,100:10	3	611,421:15	4	621,421:15	4
128,102:13	3	126,101:10	3	613,420:15	4	606,421:15	4
121,111:12	3	126,110:12	3	591,420:15	4	595,421:15	4

124,98:102	3	123,97:119	3	610,417:15	4	621,422:15	4
118,98:124	3	115,108:12	3	621,423:15	4	616,427:16	4
109,105:12	3	130,104:12	3	621,420:15	4	607,419:15	4
116,105:12	3	121,107:12	3	620,420:15	4	597,423:15	4
128,100:59	1	114,101:12	3	600,422:15	4	621,423:15	4
106,107:12	3	123,101:13	3	621,418:15	4	608,424:15	4
135,103:13	3	123,100:13	3	609,424:15	4	607,423:15	4
131,117:13	3	114,106:13	3	621,428:18	4	604,424:51	2
118,96:124	3	114,108:11	3	621,420:15	4	621,421:14	4
131,99:107	3	129,99:117	3	621,424:15	4	609,420:15	4
123,107:11	3	130,104:11	3	618,425:16	4	617,419:16	4
131,102:13	3	125,100:13	3	621,424:15	4	621,420:15	4
120,107:11	3	118,103:11	3	621,420:15	4	620,424:15	4
128,100:10	3	109,103:11	3	595,429:15	4	599,424:15	4
112,102:11	3	129,102:11	3	621,422:15	4	621,424:15	4
NaN,NaN:N	0	116,103:12	3	NaN,NaN:N	0	603,420:14	2
	0	123,94:137	3		0	621,421:::	1
	0	::591,367	1		0		0
::109,438	0	133,107:11	3	604,424:31	1	619,418:::	1
133,437:13	1	107,106:11	3	621,425:13	3	619,421:15	4
142,108:10	3	124,107:12	3	621,426:51	2	611,424:15	4
125,101:59	1	121,113:12	3	621,423:15	4	621,428:51	1

EVALUATION OF THE IVIMEDS' STROKE MODULES

Please type an X in the appropriate box to indicate your level of agreement with the following statements

YOUR STUDENT NUMBER:	**Strongly Disagree**	**Disagree**	**Unsure**	**Strongly Agree**	**Agree**
1. The IVIMEDS' learning modules helped me to achieve my learning objectives					
2. The IVIMEDS' learning modules were written in a way I could understand					
3. The IVIMEDS' learning modules helped me to consolidate my clinical reasoning skills					
4. The IVIMEDS' learning modules helped me to improve my diagnostic skills					
5. The formative assessment exercises in the IVIMEDS' learning modules helped me to consolidate my learning					
6. The IVIMEDS' learning modules made it easy for me to learn on my own					
7. The IVIMEDS' learning modules was written at the right level for me					
8. The IVIMEDS' learning modules helped me to learn things about stroke I would not have learned using other resources					
9. The content of the IVIMEDS' learning modules was clinically relevant					
10. The way the IVIMEDS' learning modules were structured was helpful to my learning					
11. The IVIMEDS' learning modules were easy to navigate and use					

FOR Q12, 1=WORSE, 2=THE SAME; 3=BETTER	**Worse**	**The Same**	**Better**
12. When comparing the IVIMEDS' learning modules to the existing resources on stroke, I think the IVIMEDS' learning module is			

	1-5 HRS/WK	**6-12 HRS/WK**	**13-19 HRS/WK**	**4=20+ HRS/WK**
13. I accessed the IVIMEDS' learning modules				

14. The best aspects of the IVIMEDS' learning modules were the following (please give as much detail as you can):

15. Aspects of the IVIMEDS' learning modules I did not find helpful included the following (please give as much detail as you can):

	YES	**NO**
16. After reflecting on the value to me of the IVIMEDS' stroke learning modules, I would recommend the School of Medicine use it in the future		

IF YOU WOULD LIKE TO MAKE ANY FURTHER COMMENTS, PLEASE FEEL FREE TO WRITE THEM ON THE BACK OF THE PAGE. THANK YOU VERY MUCH FOR BEING INVOLVED.

DH Department of Health

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5th June 2006

CURATION OF THE SCHEUER COLLECTION OF JUVENILE SKELETAL REMAINS

As HM Inspector of Anatomy for Scotland I make routine inspections to all departments of anatomy licensed under the Anatomy Act 1984.

On May 3rd 2006 I conducted a routine inspection of the Department of Anatomy and Anthropology of Dundee University. During this visit, I was shown to the room, which holds the Scheuer collection of juvenile skeletal remains and the contents were explained to me, as the collection is to be held in a licensed anatomy department.

As this collection was not held in the Department of Anatomy at my previous inspection, I made a careful check and particular note of the contents, and of the origins of the various bony specimens held. I have made subsequent enquiries regarding their origin and provenance.

The available information about the origins of the skeletons and bones in this collection is that these were either held by licensed anatomy departments in Scotland and other parts of Great Britain before February 1988 under the terms of 1832 Anatomy Act; or, were in the personal possession of Professor Susan Black prior to 1988. The latter category includes some specimens previously held in the anatomy departments of the medical schools of the Royal Free Hospital and St Thomas' Hospital, London. None of these skeletons or bones can be traced to an individual person. The available records suggest that most if not all specimens antedate the Human Tissue Act, 1961, and were mostly imported from the Indian sub-Continent.

The available documentation is sparse, but there is nothing to suggest that any of these remains were from ethnic communities, in particular from those community who have asked for the return of skeletal remains that were brought to Great Britain for anthropological research.

The information about the provenance of the collection was provided to me by Professor Black. Based on this, I am satisfied that the skeletons and bones in the Scheuer collection were lawfully held under the 1832 Anatomy Act in various licensed departments, before they came into the possession of Professor Black. The collections from the Royal Free Hospital and St Thomas' Hospital were specifically transferred to her possession from these anatomy departments. At the time the various specimens were obtained prior to 14th February 1988 it would have been lawful for anatomy departments to obtain and hold these skeletons and bones.

Based on the information available to me, I consider there is no reason why the Scheuer collection cannot be stored in the licensed Department of Anatomy and Anthropology at Dundee University.

J S Metters
HM Inspector of Anatomy for Scotland

Appendix 4

Key:

- <hyperlink> - these words will link to a journal/website
- red words - These relate to instructions for images/animations/speech
- Coloured words relate to the same colour on the image below.
- **Bold** words (except titles) will be defined in a glossary or on an image.

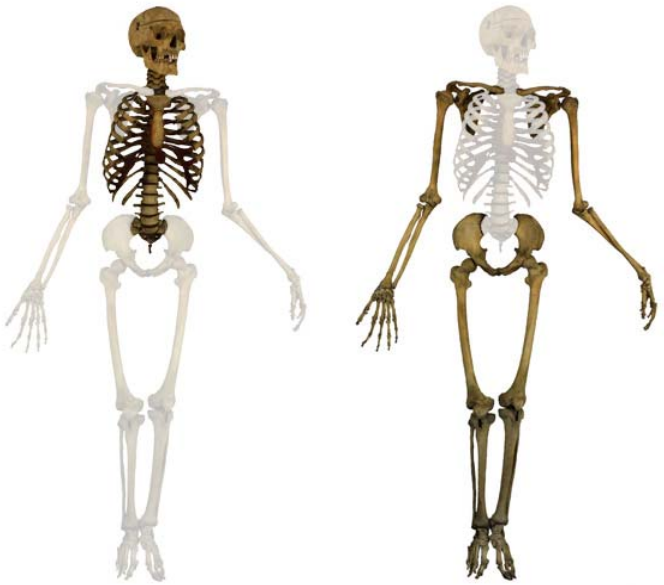
Tutorial 1 - Introduction to the pelvis and innominate
Tutorial 2 - Primary ossification of the innominate
Tutorial 3 - Maturation of the acetabulum
Tutorial 4 - Secondary ossification of the innominate

- Adult test taken before and after tutorial 1.
- Initial evaluation taken after tutorial 1.
- Juvenile test taken after tutorial 1 and 4.
- Final evaluation taken after tutorial 4

- **Students will take adult test**
- **The initial evaluation will be taken**

Tutorial 1 - Introduction to the Pelvis

The pelvis is a girdle of the skeleton which provides a junction between the midline trunk **(axial skeleton)** and the lower limb **(appendicular skeleton).**

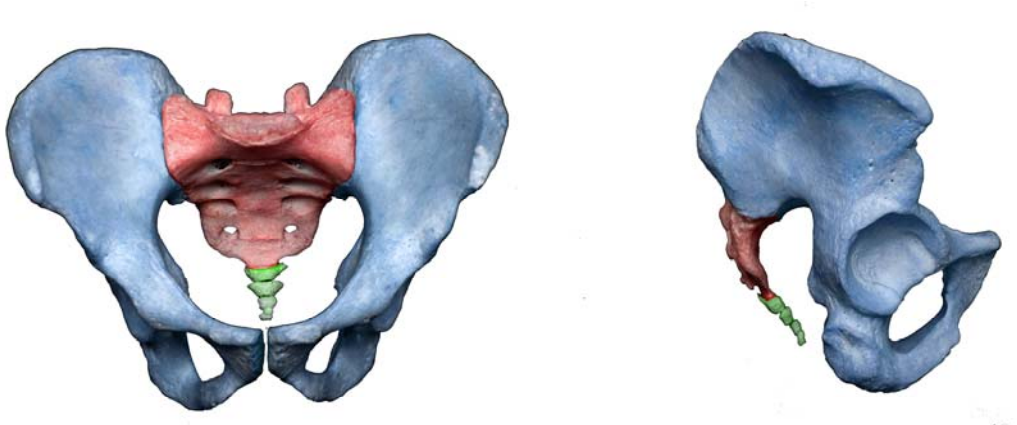


Axial Skeleton Appendicular Skeleton

- 2D image

<Hyperlink to anatomical terminology>

Four bony elements comprise the pelvic girdle: the **right and left innominates** (Latin: "nameless"), the **sacrum** and the **coccyx**.



- 2D image

Articulations

Within the pelvic girdle, the **right and left innominates** articulate anteriorly with one another via a **secondary cartilaginous** joint <hyperlink> at the **pubic symphysis;** and posteriorly with the **sacrum** at the **sacro-iliac joint**, which is both **synovial and primary cartilaginous** <hyperlink>. The **coccyx** articulates with the **sacrum** via a primary cartilaginous joint.

Outwith the pelvic girdle, the **right and left innominates** articulate with the lower limb (femur) via a synovial joint. The **sacrum** and **coccyx** form the lowest part of the vertebral column, articulating superiorly via a secondary cartilaginous joint to the lowest lumbar vertebra.

Functions

1. Weight bearing <hyperlink>
2. Erect posture and bipedal locomotion <hyperlink>
3. Safe passageway for fetal head <hyperlink>
4. Haemopoietic function <hyperlink>

Sexual Dimorphism

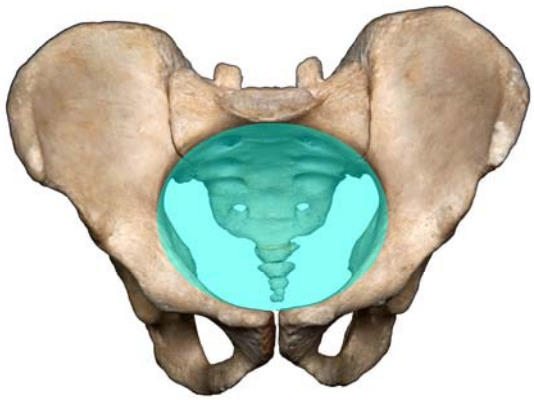
Sexual differences in the pelvis become readily apparent following puberty due to the functional differences between males and females, (i.e. childbirth) making the pelvic girdle the most sexually dimorphic part of the skeleton.

Male **Female**

- 2D image

Relation to Soft Tissues

The **pelvic brim** divides the pelvic girdle into a superior **false pelvis** and an inferior **true pelvis**. The **false pelvis** houses inferior portions of the abdominal organs. The **true pelvis** houses the pelvic organs.



- 3D rotation with pelvic brim separating true and false.

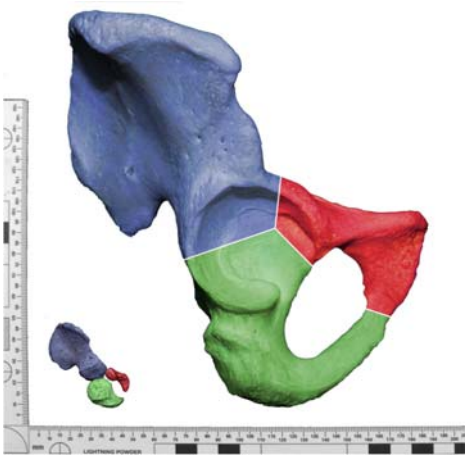
Surface Anatomy

The **iliac crest, anterior superior iliac spine, pubic tubercle, spinous processes of the sacrum, and the coccyx** can be palpated through the skin. <3D rotation>

- 3D rotation. List of landmarks. Click on text for highlighted features.

The Innominate

Developmentally, the innominate is the result of fusion of **three** bones: **ilium**, **ischium** and **pubis.**



Perinate **Adult**

- 2D image

The ilium, ischium and pubis can be followed through development.

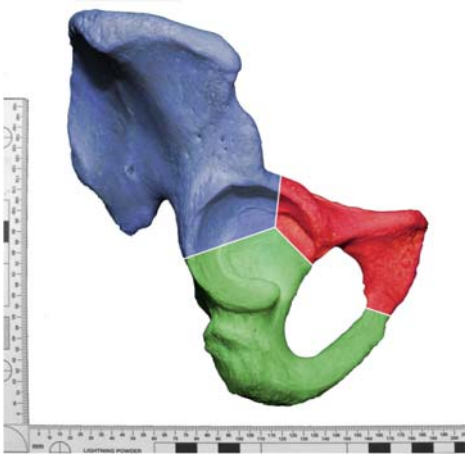
Birth **6 yrs** **15 yrs** **Adult**

- 2D image. Student to click image to continue to the next page.

Adult Innominate

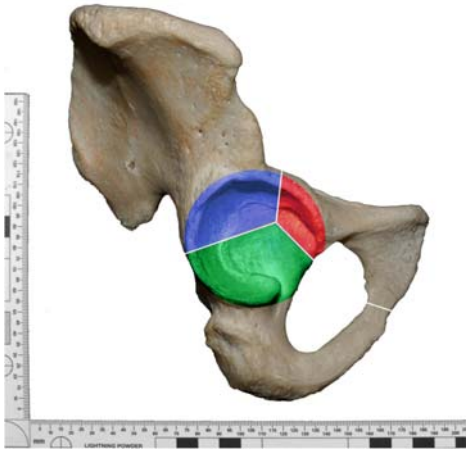
Introduction

The borders of the **ilium**, **ischium** and **pubis** can be identified in the adult



- 3D rotation of innominate, highlighting the 3 elements or 2D

All three elements of the innominate contribute to the acetabulum



- 2D image of the acetabulum, highlighted and borders marked

The **ischium** and **pubis** both contribute to the obturator foramen

- 2D image of obturator foramen

Ilium

- 3D rotation. flash movie with sound, talking through landmarks, highlighting, landmarks also listed for students to click to highlight (without speech).

Landmarks of the ilium - click to highlight

- iliac crest, ASIS, AIIS, PSIS, PIIS,
- iliac fossa,
- sacropelvic surface, auricular, post auricular surface,
- pelvic surface, iliopectineal line, greater sciatic notch,
- gluteal surface,
- acetabulum

Example of text/sound - can be switched on/off

"The ilium is the most superior element of the pelvic girdle. Its superior limit, the iliac crest, extends anteriorly to the anterior superior iliac spine and posteriorly to the posterior superior iliac spine. The anterior and posterior inferior iliac spines are also part of this bone.

- Highlight iliac crest, ASIS, AIIS,PSIS and PIIS

Anteriorlo medially, the iliac fossa and sacropelvic surfaces can be identified. The iliac fossa provides surface area for muscle attachment whilst the sacropelvic surface contributes to the auricuar and postauricular elements of the sacroiliac joint.

- zoom in to auricular surface, label landmarks, include hyperlink to paper.

The pelvic surface of the ilium is bound superiorly by the ileopectineal line and contributes to the greater sciatic notch.
The gluteal surface can be seen posterolaterally, which provides muscle attachment for the glute muscles.

- highlight borders and muscle attachments

The ilium contributes to two fifths of the acetabulum, and the entire innominate surface for the sacroiliac joint."

- Highlight borders of acetabulum

Ischium

- 3D rotation. flash movie with sound, talking through landmarks, highlighting, landmarks also listed for students to click to highlight (without speech).

Example of text/sound - can be switched on/off

" The ischium contributes to the lower posterior portion of the innominate. It is comprised of an upper body and a lower ramus.

- highlight body and ramus

It extends superiorly to its articulation with the ilium dorsally and at the acetabulum where it also articulates with the pubis contributing to two fifths of the acetabulum

- highlight articulations

Inferiorly the ischium extends to its tuberosity and the iscial ramus, where it articulates with the pubis anteriorly.

- highlight tuberosity

Posteriorly the ischium extends to the iliac spine and the border of the lesser sciatic notch"

- highlight spine and lesser sciatic notch

Landmarks of the ischium - click to highlight

- body
- ramus
- articulation with ilium
- articulation with pubis
- tuberosity
- iliac spine
- lesser sciatic notch

Pubis

- 3D rotation. flash movie with sound, talking through landmarks, highlighting, landmarks also listed for students to click to highlight (without speech).

Example of text/sound - can be switched on/off
"The pubis is made up of a body which houses the pubic crest and pubic tubercle.

- Highlight pubic body, crest and tubercle

And two rami, the superior pubic ramus and the inferior pubic ramus"

- Highlight superior and inferior rami

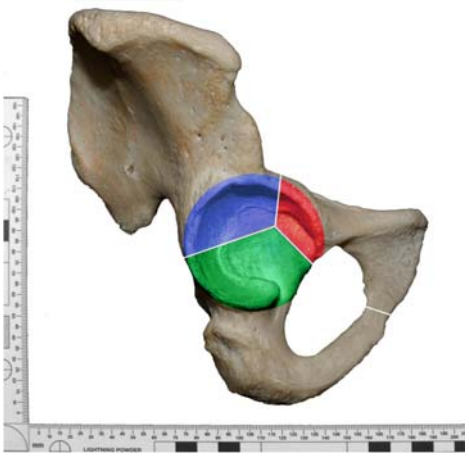
Landmarks of the pubis – click to highlight

- Pubic body
- Pubic crest
- Pubic tubercle
- Superior pubic ramus
- Inferior pubic ramus

Acetabulum

The acetabulum is a region of the innominate common to the **ilium**, **ischium** and **pubis.**

- 2D (or 3D) image as flash movie with sound, talking through landmarks, highlighting, landmarks also listed for students to click to highlight (without speech).



Example of text/sound - can be switched on/off
"Created by the fusion of the ilium, ischium and pubis, the actebulum comprises an articular region, for the articulation with the head of the femur and a non-articular area.

- Show demarcation at all times. Highlight articular and non articular

The smooth horseshoe shape of the articular region of the acetabulum is covered with hyaline cartilage in the living. The rough area of the non articular region contains fatty tissue in the living and opens out to the acetabular notch, where the transverse ligament attaches."

- Highlight acetabular notch

Landmarks of the acetabulum – click to highlight

- Borders of ilium, ischium and pubis
- Articular region
- Non articular region
- Acetabular notch

- **Students will take adult test for the second time**
- **Students will take a test on the development of the innominate**

Tutorial 2 - Ossification of the innominate

Introduction

Bone development, scientifically known as ossification can be used by forensic anthropologists to aid in the determination of age from unknown remains.

The initial site of ossification is known as the primary ossification centre. This may go on to form the entirety of the adult bone, or may form the majority of the adult bone and fuse to additional centres (secondary centres). <hyperlink to ossification website>

- 2D image showing femur with separate epiphyses - label shaft as primary centre, proximal and distal epipyses as secondary

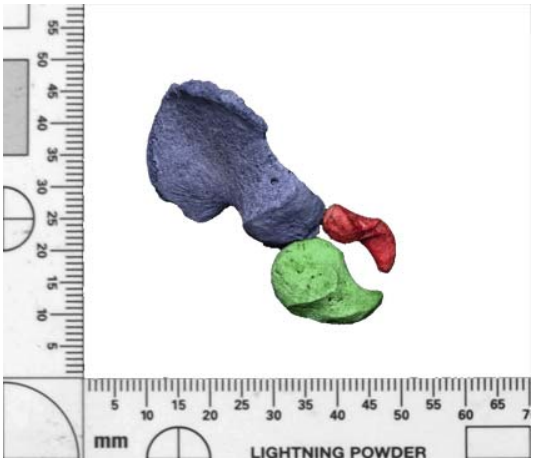
Secondary ossification centres (epiphyses) are separated from the primary centre by an organised cartilaginous region (growth plate). As the primary centre grows, the plates move away from the body or shaft and fusion of the primary and secondary centres marks the end of growth.

- 2D diagram - label primary and secondary centre and growth plate
- 2D fash movie - diagram "grows" and eventually fuses

Appearance and fusion of ossification centres (both primary and secondary) occur in a relatively organised sequence throughout the developing skeleton and this is useful when determining age of skeletal remains. As a forensic anthropologist you can never be certain of what remains you will be presented with, and assignation of age is important when attempting to identify the deceased. Therefore, knowledge of the entire skeleton is essential from minute fragments to entire remains, and from the developing child to the ageing adult.

Primary Ossification

The adult innominate is created from the fusion of three bony elements; the **ilium**, **ischium** and **pubis**



- 2D image

Three primary centres of ossification appear before birth in the innominate; one for the ilium (3rd uterine month) another representing the ischium (4th-5th uterine month) and another for the pubis (5th-6th uterine month).

By birth, some characteristic features are already present.

Landmarks of the perinate Ilium
Find:
Iliac crest
anterior superior iliac spine
posterior superior iliac spine
greater sciatic notch (upper border)
auricular surface
acetabulum

- 3D rotating SAD ilium. Students click to identify landmarks
- Hints available (speech below)

"At birth many characteristic features of the ilium are readily identifiable; the radiating shell appearance of the bone, the presence of the upper border of the greater sciatic notch in addition to the developed anterior superior and posterior superior iliac spines. The iliac crest is distinctly S-shaped at birth, however the concavities and convexities of the iliac and gluteal surfaces do not fully develop until around 2years of age when the anterior border bends forward. The acetabulum can be identified as a slight depression inferolaterally."

Landmarks of the perinate ischium
Find:
Pelvic surface
Acetabular fossa
Developing ramus

- 3D rotating SAD ischium. Students click to identify landmarks
- Hints available (speech below)

"The anteriorly pointing comma or apple seed appearance of this bone allows it to be identified by the third trimester of pregnancy. At birth the superior, posterior and inferior borders are convex, while the anterior border is concave. A depression can be identified on the outer surface due to the developing acetabular fossa. The inner aspect is smooth."

Landmarks of the perinate pubis
Find:
Iliac surface
Acetabular surface

- 3D rotating SAD ischium. Students click to identify landmarks
- Hints available (speech below)

"The developing pubis is very small and delicate and is rarely recovered from prenatal remains. It can be identified as a dumb-bell-shaped. The lateral (iliac) surface is rounded while the medial (symphyseal) end is flatter, projecting vertically downwards. The inner aspect is relatively featureless compared to the outer aspect where the pecten pubis passes. An oval acetabular surface can be identified"
The morphology of the ilium, ischium and pubis changes very little for the next few years. The initial rapid growth in the first few months slows until 2-3years and then slows further until early puberty.

- 3D rotating P9.
- Students must identify landmarks

Landmarks from a six year old innominate
Find on the ilium:

- iliac crest, ASIS, AIIS, PSIS, PIIS,
- iliac fossa,
- sacropelvic surface, auricular, post auricular surface,
- pelvic surface, iliopectineal line, greater sciatic notch,
- gluteal surface,
- acetabulum

Find on the ischium:

- body
- ramus
- articulation with ilium
- articulation with pubis
- tuberosity
- iliac spine
- lesser sciatic notch

Find on the pubis:

- Pubic body
- Pubic crest
- Pubic tubercle
- Superior pubic ramus
- Inferior pubic ramus

Fusion can be seen in the innominate in the region of the inferior ramus. This occurs between 5-8years.

- 2D image of P9, labelled with fusion of ramus

A cartilage template separates the ilium, ischium and pubis in the region of the acetabulum.

- 3D rotation with cartilage space highlighted

Tutorial 3 - Maturation of the acetabulum

Maturation of the acetabulum is a complex process. From an early age, an acetabular surface can be identified on each of the three primary ossification centres of the innominate; the **ilium**, **ischium** and **pubis**.

- 2D image - colour in acetabular region only

Acetabular region of the ilium, ischium and pubis

Perinate 6 years

During the development of the innominate, a cartilage template is present in the region of the acetabulum. This cartilage template allows expansion of the acetabulum to accommodate the growing femoral head. Complete fusion of this region marks the end of acetabular growth.

Maturation of the acetabulum is best described from a three dimensional point of view. Three types of cartilage are present in the developing acetabulum

- growth <hyperlink definition>
- epiphyseal <hyperlink definition>
- articular <hyperlink definition>

The cartilaginous template is composed of a cup shaped articular area and connects to a triradiate element

- 3D freeform - highlight cup and triradiate
- 2D A11 to compare

In general, there are three main epiphyses which form the cup-shaped acetabular cartilage. These ultimately fuse with the ossifying triradiate epiphysis.

- 3D rotating A11. Highlight 3 epiphyses and triradiate ossification
- Speech with flash movie or notes within flash (")

The triradiate cartilage consists of three flanges:
Anterior
Posterior
Vertical
Both growth and epiphyseal cartilage is found here

- 2D image (or 3D) highlighting flanges and cartilage

Epiphyses of the acetabulum
Find
Os Acetabuli - "appears between 9 and 10 years, extends to the anterior flange of the triradiate and forms part of the articular rim (highlight region on flash). This also extends and fuses with he superior epiphysis."
Posterior epiphysis - "Appears between 10 and 11years, extends to the posteror flange of the triradiate and forms the posterior rim and lower part of the articular surface (highlight on flash)."
Superior epiphysis - "appears between 12 and 14years, forms the upper part of the acetabular rim and does not extend to the triradiate.
Triradiate -"Around the age of 9 years the triradiate cartilage displays a number of small ossific islands. Fusion of the acetabulum commences around 11 in females and 14 in males and is completed 3-4 years later."

- 2D (or 3D) image A11

The epiphyses in the region of the acetabulum fuse in advance of the other epiphyses of the innominate.

Tutorial 4 - Secondary ossification of the innominate

Anterior inferior iliac spine

- 2D image (") for text within flash or speech. highlight age of specimen

"Appears between 10-13 years, fuses to the ilium by 20 years"
Iliac crest
"Appears from two centres around 12-14 years in females and 14-15 years in males. Ossification begins in the midline. One centre extends anteriorly, the other posteriorly. These fuse to each other 17-20 in females, 19-21 in males and fuse to the ilium by 23 years."

- 2D image (") for text within flash or speech. highlight age of specimen

Ischial epiphysis (ramal epiphysis)
"Appears between 13-16years on the ischial tuberosity and extends along the ischial ramus. Fusion commences around 16-18 years, and is complete by 23 years.

- 2D image (") for text within flash or speech. highlight age of specimen

Pubic symphysis
The dorsal and ventral demifaces of the pubic sympysis mature as two distinct surfaces.

- 2D image highlighting faces

Age ranges have been assigned to the process of maturation of the pubic symphysis.

Pre-epiphyseal phase - 13 years

- 2D image with explanation pop up

Gradual infilling of the dorsal demiface - 15-23 years

- 2D image with explanation pop up

Development of the ventral rampart - 23-30 years

- 2D image with explanation pop up

Pubic tubercle epiphysis 23-25 years

- 2D image with explanation pop up

Formation of the dorsal plateau - 18-30 years

Full maturation of the innominate may not be evident until 35-40 years, however, generally, maturation is complete by 30 years.

- **Students will take a test on the development of the innominate**
- **Students will take final evaluation**

Tutorial 1 - Introduction to the Pelvis

Click on the above link to start tutorial 1. It is split into 2 parts:

Part 1 - Introduction

Part 2 - Adult innominate.

Once you have completed part 1 and marked it as reviewed by clicking the Not Reviewed button. Part 2 will become activated. A test and an evaluation will be activated after completing part 2.

A glossary and anatomical terms pages are available for your use. These are located at all times on the left side of the screen and will open in the current window. To return to the section you were working on click the "back" button on your internet browser. In some instances there are links to these within the module, these will also appear in the same window.

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If you have any problems regarding the module please direct your queries to the discussionboard or e-mail me
k.tyldesley@dundee.ac.uk

Tutorial 1 - Introduction to the Pelvis

Part 1- Introduction

Objectives:

- Understand anatomical location terms with regard to the pelvis
- Understand and be able to describe what bones contribute to the pelvic girdle
- Understand and be able to describe the functions of the pelvic girdle
- Understand and be able to describe the bony pelvis and its relation to soft tissues
- Understand and be able to describe the surface anatomy of the pelvis (what can be felt in life)
- Understand there is a difference between male and female pelves

1. Pelvic Girdle 1

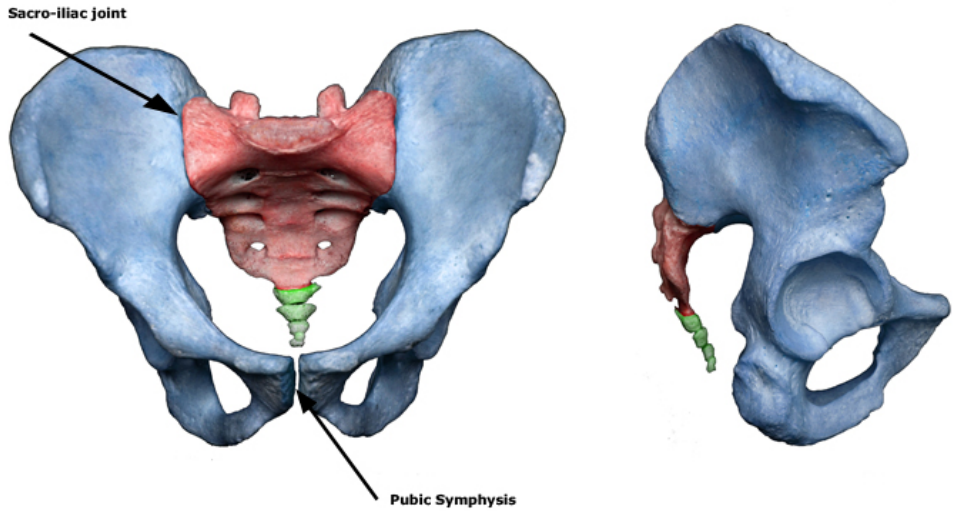
The pelvis is the lower limb girdle of the skeleton which provides a junction between the midline trunk **(axial skeleton)** and the lower limbs **(appendicular skeleton).**

Axial Skeleton

Appendicular Skeleton

2. Pelvic Girdle 2

Four bony elements comprise the pelvic girdle: the **right and left innominates,** the **sacrum** and the **coccyx**.



Within the pelvic girdle, the right and left innominates articulate anteriorly with one another via a secondary cartilaginous joint at the **pubic symphysis**; and posteriorly with the sacrum at the **sacro-iliac joint**. Often characterised as a synovial joint, the sacro-iliac joint also displays ligamentous articulation between the sacrum and ilium leaving the anterior third of the joint truly synovial, and the posterior two thirds ligamentous (therefore a mixed joint); Cohen, (2005).

The right and left innominates articulate with the lower limb (femur) via a synovial joint. The sacrum and coccyx form the lowest part of the vertebral column, articulating superiorly with the lowest lumbar vertebra via a secondary cartilaginous joint (body) and a synovial joint (articulating facets).

- Weight bearing Scholten et al. (1988).
- Erect posture and bipedal locomotion - *" Why did our ancestors become bipeds and not quadripeds?"* Preuschoft (2004).
- Safe passageway for fetal head Rosenberg and Trevathan (2002).
- Haemopoietic function (formation of blood).

4. Relation to soft tissues

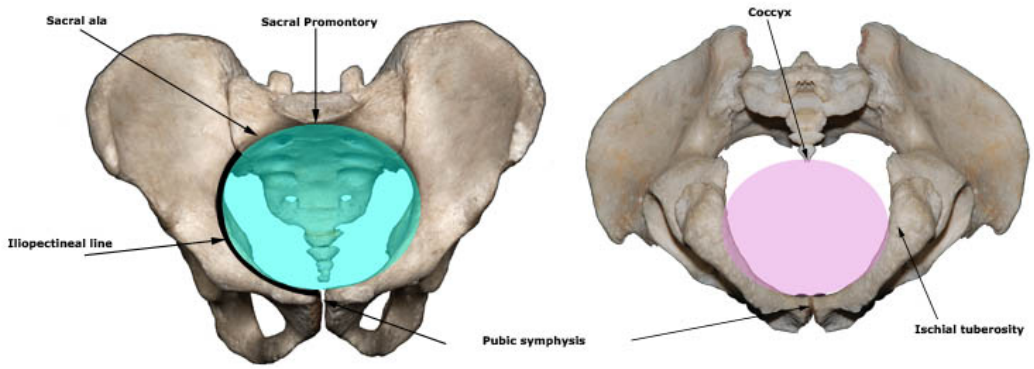
The **pelvic brim** (pelvic inlet) divides the pelvic girdle into a superior false pelvis and an inferior true pelvis.

Inferior portions of the abdominal organs are housed within the false pelvis.

Pelvic organs are situated in the true pelvis which lies between the pelvic brim and **pelvic outlet**.

The **sacral promontory**, **sacral alae, iliopectineal lines**, and **pubic symphysis** create the pelvic brim.

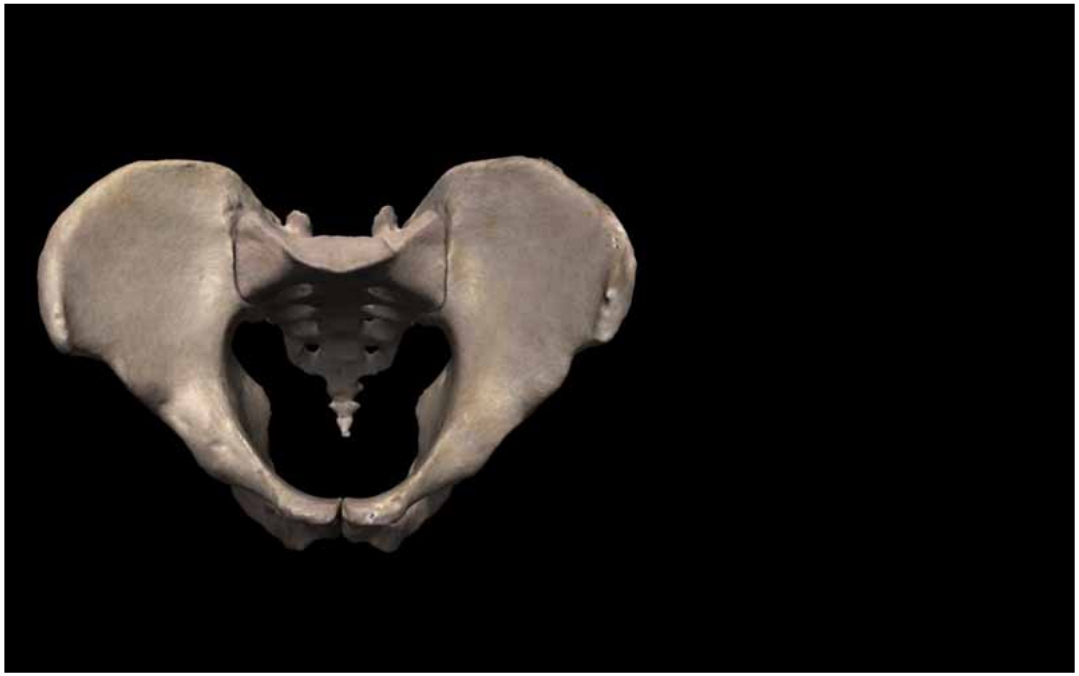
The pelvic outlet is created from the **coccyx, ischial tuberosities** and the **pubic symphysis**.



5. Surface anatomy

A number of features on the pelvic girdle can be palpated through the skin.

Use your mouse to rollover features which can be palpated through the skin. Click and drag to rotate the pelvis.



Note: Iliac crests, pubic tubercles, spinous processes and ischial tuberosities should be palpable.

6. Sexual Dimorphism

Sex related differences in the pelvis become readily apparent following puberty due to the biochemical and functional differences between male and female, (i.e. hormonal differences and childbirth) making the pelvic girdle the most sexually dimorphic part of the skeleton.

Male

Female

For your interest:

- Bruzek (2002) - A method for visual determination of sex, using the human hip bone
- Gonzalez *et al.* (2007) - Analysis of dimorphic structures of the human pelvis: its implications for sex estimation in samples without reference collections

7. Review

Not Reviewed

You have completed part one of the tutorial.

Mark this page as reviewed (right) to activate part 2.

Tutorial 1 - Introduction to the Pelvis

Part 1- Introduction

Objectives:

- Understand anatomical location terms with regard to the pelvis
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- Understand there is a difference between male and female pelves

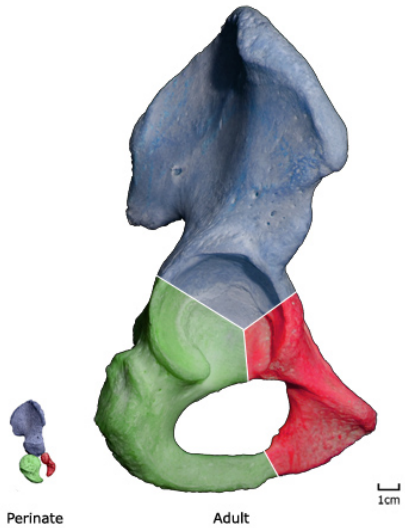
Part 2 - Adult innominate

Objectives:

- Understand that three bones articulate to create the innominate
- Understand basic morphology of the adult innominate
- Understand and be able to identify features and surfaces of the adult ilium
- Understand and be able to identify features and surfaces of the adult ischium
- Understand and be able to identify features and surfaces of the adult pubis

OK

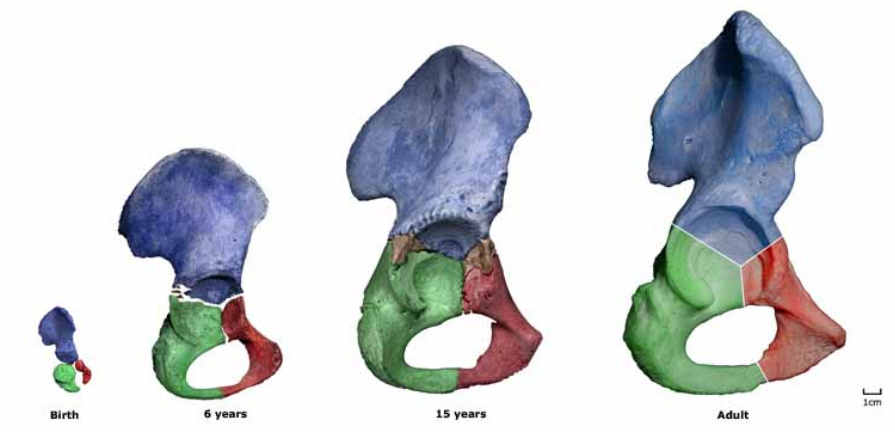
1. Innominate 1



Perinate Adult

Developmentally, the innominate is the result of the fusion of three bones: **ilium**, **ischium** and **pubis**.

2. Innominate 2

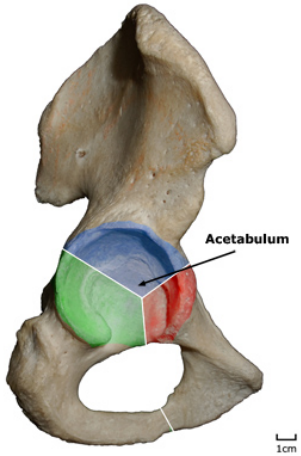


The **ilium**, **ischium** and **pubis** can be followed through development.

Initial knowledge of the adult form of the innominate will aid in the understanding of its development.

Lateral view Medial view

The borders of the: **ilium**, **ischium** and **pubis** can be identified in the adult.

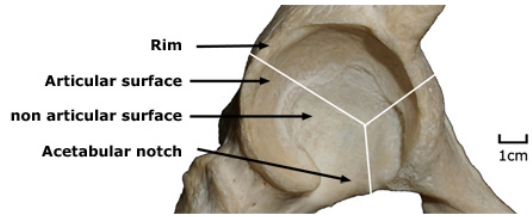


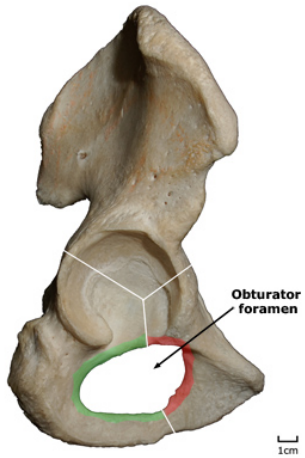
Lateral view

All three elements of the innominate contribute to the **acetabulum**.

The acetabulum provides the articulation site for the head of the femur.

The ilium and ischium each contribute to two fifths of the acetabulum, the pubis the remaining fifth.

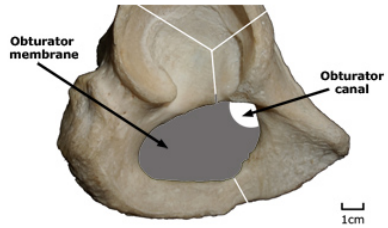




Lateral view

The **ischium** and **pubis** both contribute to margins of the obturator foramen.

In the living the foramen is covered by a **membrane** except in the region of the obturator canal through which passes the obturator nerve and vessels.



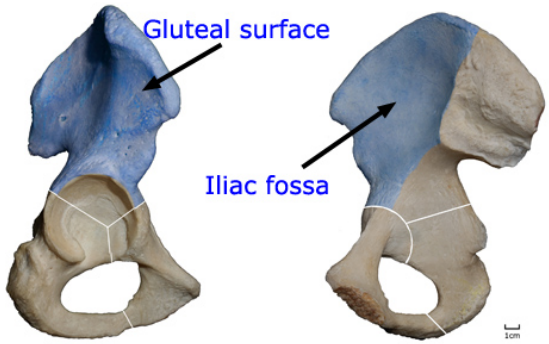
6. Ilium 1

Lateral view

Medial view

The **ilium** is the most superior element of the pelvic girdle.

7. Ilium 2



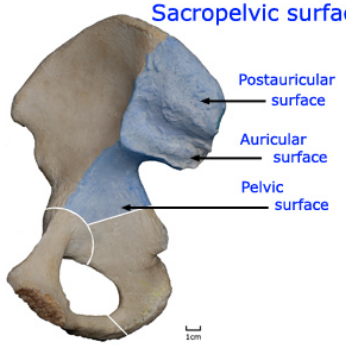
The **gluteal surface** is seen posteriolaterally.

This surface provides muscle attachment for the gluteal muscles.

The **iliac fossa** on the medial surface of the innominate also provides attachment for the iliacus muscle.

For muscle attachments click here - Muscle attachments.jpg

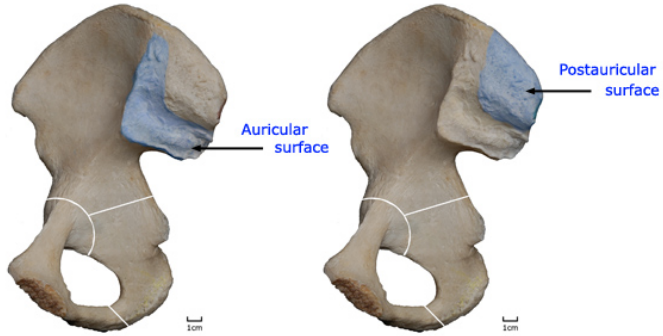
Sacropelvic surface



The medial surface of the ilium is split into the iliac fossa and **sacropelvic surface**.

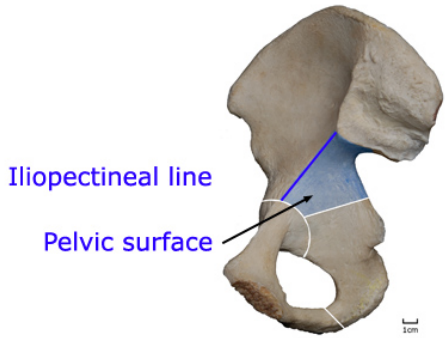
The sacro pelvic surface is further split into **postauricular**, **auricular** and **pelvic** surfaces.

9. Ilium 4



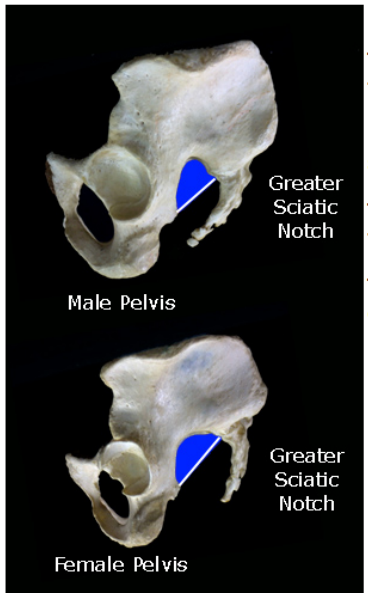
The ear-shaped (or L-shaped) **auricular surface** is the site of the synovial sacroiliac joint.

The posterior, superior **postauricular** region is a site for ligamentous attachment.



The **iliopectineal** line separates the iliac fossa from the pelvic surface.

The **pelvic surface** forms part of the greater sciatic notch.



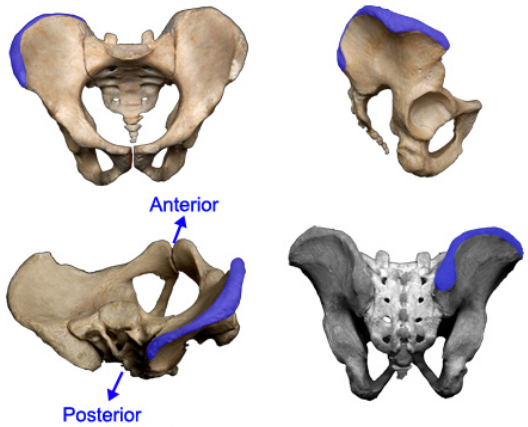
The **greater sciatic notch** is a deep indentation of the innominate at the point of union of the ilium and ischium.

In life the notch is converted into a foramen by the attachment of the sacrospinous ligament shown here by a white line.

The piriformis muscle, and a number of nerves and vessels pass through the foramen.

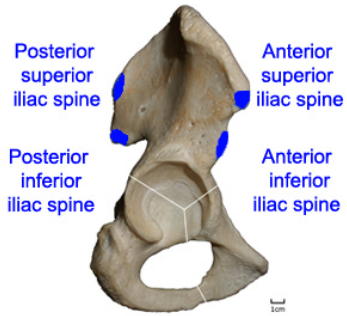
This indentation is highly sexual dimporphic, note the narrow V-shape of the male compared to the wide U-shape of the female .

Further reading: Walker, 2005



The superior limit of the ilium is the S- shaped **iliac crest**.

In the juvenile innominate, the iliac crest forms from seperate elements which later fuse to the rest of the ilium



The iliac crest extends posteriorly to the **posterior superior iliac spine** and anteriorly to the **anterior superior iliac spine.**

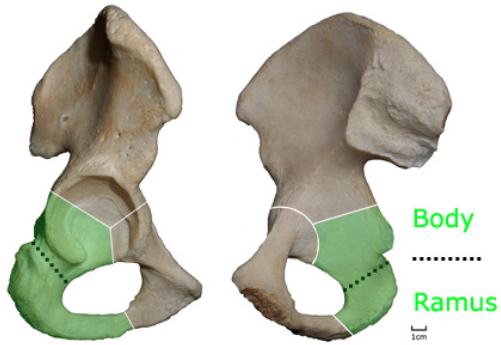
The four spines (left) are projections of the ilium created from muscle and ligamentous attachments.

14. Ischium 1

Lateral view

Medial view

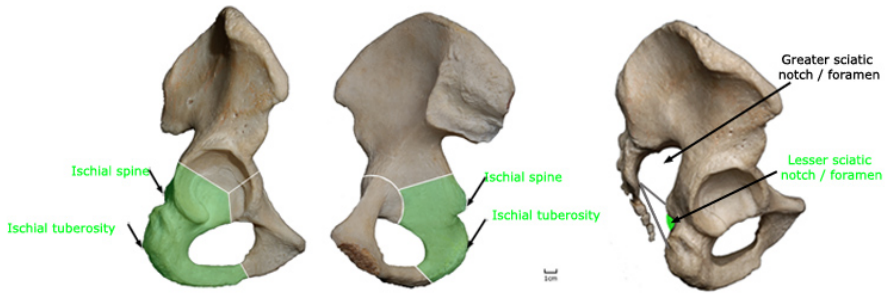
The **ischium** forms the lowest most posterior region of the innominate.



The **ischium** can be separated into an upper body and a lower ramus.

The body extends into the acetabulum to articulate with the iluim and pubis whilst the ramus extends anteriorly to articulate with the pubis.

16. Ischium 3



The **ischial tuberosity** and **spine** can be seen medially and laterally.

The tuberosity supports the body in an upright seated position.

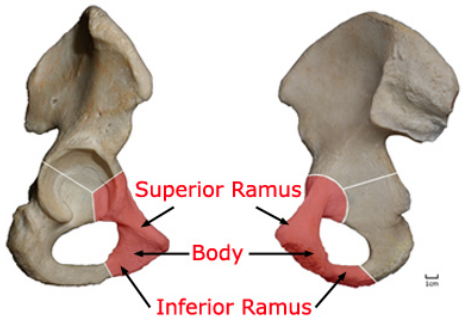
The ischium extends posteriorly to the ischial spine which provides the distal attachment for the **sacro spinous ligament** (seen above right) and converts the **lesser sciatic notch** into a **foramen** along with the **sacro tuberous ligament**.

The tendon of the obturator internus muscle and the pudendal nerve and vessels pass through the lesser sciatic foramen.

Lateral view

Medial view

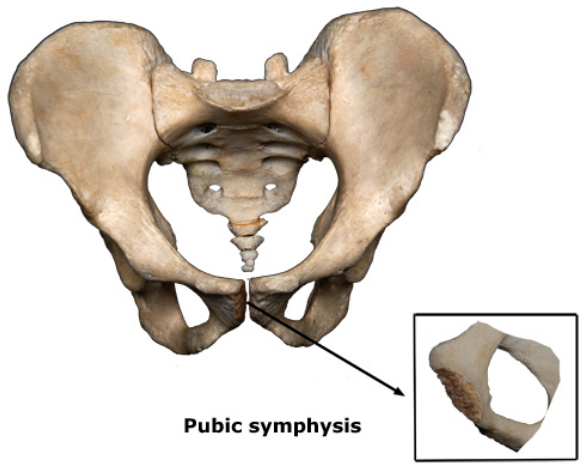
The **pubis** forms the ventral lower part of the innominate.



The **pubis** has a **body** and two **rami (superior and inferior).**

The superior ramus extends into the acetabulum to articulate with the ilium and ischium.

The inferior ramus extends posteriorly to articulate with the ischial ramus (ischiopubic ramus).



Pubic symphysis

The **pubic symphysis** is the site of articulation in the midline of each innominate.

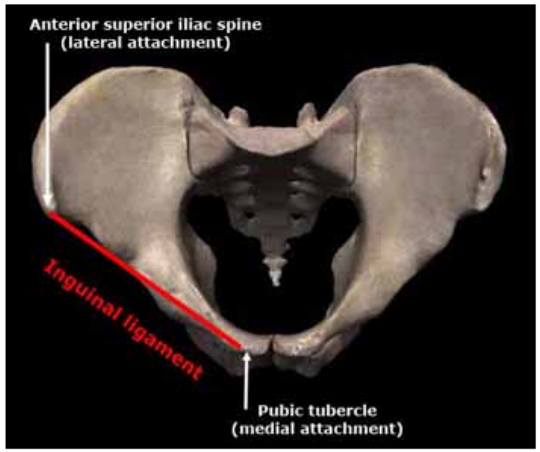
This secondary cartilaginous joint does not fuse and retains a cartilaginous band between each pubis.

This region of the pubis is considered highly accurate for assessing age as there are a number of developmental changes seen here following puberty. The pubic symphysis is also considered one of the most sexually dimorphic regions of the skeleton.

20. Pubis 4

Lateral view

The **pubic tubercle** is a small projection from the pubic body provides attachment for the inguinal ligament.



Click the link below for a labelling activity.

Adult.swf

The above link should open in a new window. Resize the window if desired and have a go.

Click the tick to submit answers and you will get feedback. Click the tick again to have another try.

Results will not be recorded.

Note: not all labels will be required.

non articular surface of acetabulum

Sacrotuberous ligament

Sacrum (anterior view)

Right greater sciatic notch

Sacrospinous ligament

Left pubic tubercle

Right greater sciatic foramen

Coccyx (lateral view)

22. Review

Not Reviewed

You have completed part one of this tutorial.

Mark this page as reviewed (right) to activate the quiz.

Developmental Osteology Test 1

Click the link above to start the test (the timer will start straight away). The test is split into 2 sections and a time limit of 10 minutes has been set for the entire test. Please allow 5 minutes for each section.

Once you have completed the test, an evaluation must be completed before tutorial 2 is available. The evaluation can be found by cicking on tutorials (left) then tutorial 1.

Developmental Osteology Tutorial 1 Evaluation

Click the link above to complete the evaluation. This does not have a time limit but should only take 10 minutes to complete.

Completion of this will activate tutorial 2

5 **Tutorial 2 - Development of the innominate**

Modify | Manage | Copy | Remove

Click on the above link to start tutorial 2. It is split into 4 parts, each of which will be activated following completion of the previous:

Part 1 - Ossification. One page explaining ossiffication, will automatically be directed to part 2.

Part 2 - Primary ossification.

Part 3 - Secondary ossification 1 - Maturation of the acetabulum

Part 4 - Secondary ossification 2 and summary.

A test and an evaluation will follow part 4.

A glossary and anatomical terms pages are available for your use. These are located at all times on the left side of the screen and will open in the current window. To return to the section you were working on click the "back" button on your internet browser. In some instances there are links to these within the module, these will also appear in the same window.

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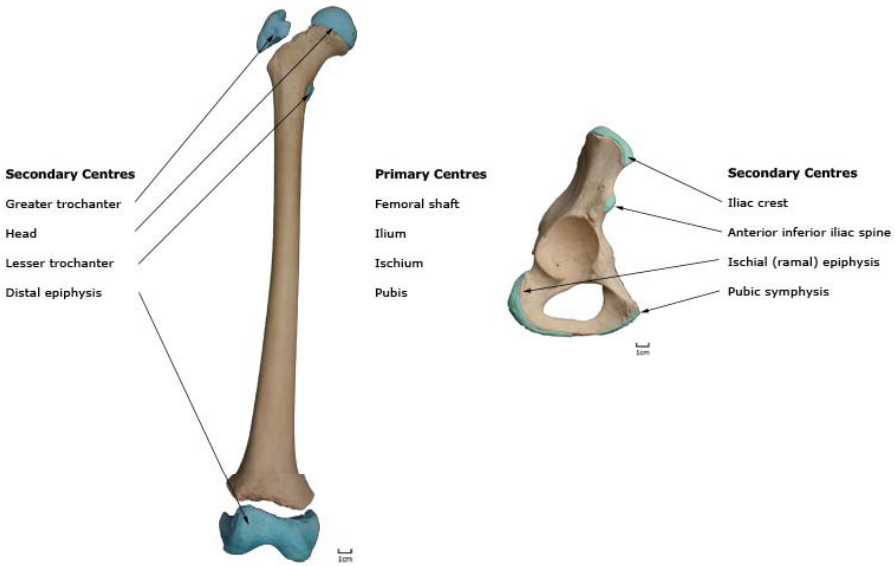
Tutorial 2 - Development of the innominate

Part 1 - Ossification

Mark Reviewed

Bone is laid down through a progressive process known as ossification. The maturation of bone can be used by forensic anthropologists to aid in the determination of age from remains as the skeleton develops in a relatively sequential and predictable pattern.

The initial site of ossification is known as the primary ossification centre. This may go on to form the entirety of the adult bone, e.g. carpals, or may form the majority of the adult bone and fuse to additional centres (secondary centres/ epiphyses), e.g. femur, innominate.



Secondary ossification centres (or epiphyses) are separated from the primary centre by an organised and active cartilaginous region (growth plate). As the primary centre grows, the plate continues to grow and remains between the primary and secondary centres until growth has stopped. Fusion of the secondary centres to the primary centre marks the end of growth.

Appearance and fusion of ossification centres occur in a relatively organised sequence throughout the developing skeleton and this is useful when determining age of skeletal remains. As a forensic anthropologist you can never be certain of what remains you will be presented with, and assignation of age is important when attempting to identify the deceased from any part of the body that may be presented. Therefore, knowledge of the entire skeleton is essential from minute fragments to entire bones, and from the developing child to the aging adult.

Useful information: Click

Mark as reviewed to continue to part 2

OK

Part 2 - Primary Ossification

Objectives:

- Understand the term ossification
- Understand the difference between primary and secondary ossification
- Understand that ossification of the ilium, ischium and pubis initiates in fetal life
- Be able to compare morphology of a juvenile innominate with an adult
- Understand fusion initially occurs in the region of the ischiopubic ramus.
- Understand the acetabular surfaces of the ilium, ischium and pubis are initially separated by cartilage in life
- Be able to label features of the juvenile ilium, ischium and pubis.

1. Introduction

The adult innominate is created from the fusion of three bony elements; the **ilium**, **ischium** and **pubis**.

Perinate 1cm

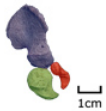
The three primary centres of the innominate all appear before birth:

Ilium - 3rd uterine month

Ischium - 4-5th uterine month

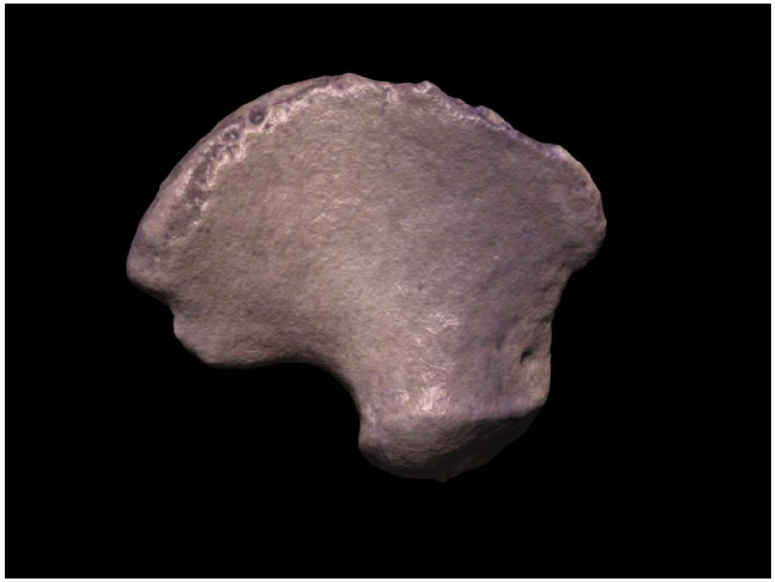
Pubis - 5-6th uterine month

2. Landmarks of a perinate ilium



The perinate ilium, ischium and pubis can be seen in the next 3 sections.

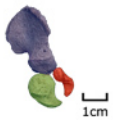
Click and drag the right ilium below to understand its morphology.



Landmarks: Iliac fossa, gluteal surface, auricular surface, acetabular surface, greater sciatic notch, future site for iliac crest.

Siding hints: When viewing the iliac fossa the acetabular surface should be pointing inferior and the future iliac crest border should be superior. The auricular surface lies to the side it comes from. i.e position the above ilium as described and note the auricular surface is on the right of the screen.

3. Landmarks of a perinate Ischium

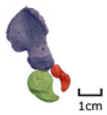


Click and drag the right ischium below to understand its morphology.

Landmarks: Ischial tuberosity, acetabular surface, pelvic surface, ischial ramus, border of the obturator foramen.

Siding hints: When viewing the acetabular surface, orientate the ramal surface so the obturator foramen border is superior. The ramal surface will point towards the side it originates. i.e. rotate the image above to view the acetabular surface and the ramal surface will point to the right side of the screen.

4. Landmarks of a perinate pubis



Click and drag the right pubis below to understand its morphology.

Landmarks: Acetabular surface, pubic symphysis, pelvic surface (featureless), lateral surface (demarcation between body and superior ramus).

Siding hints: When viewing the lateral surface, place the pubis on a horizontal plane. The pubic symphysis will point to the side it's from, the acetabular surface will point to the opposite.

5. Perinate drag and drop activity

Click the link below for a labelling activity.

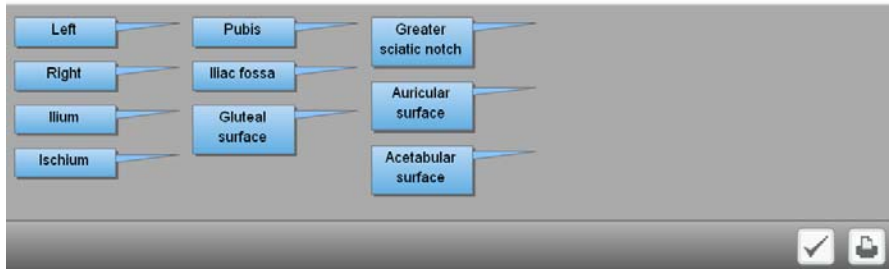
Note: some labels may not be required.

Perinate.swf

The above link should open in a new window. Resize the window if desired and have a go.

Click the tick to submit answers and you will get feedback. Click the tick again to have another try.

Results will not be recorded.



6. Landmarks of a 6 year old

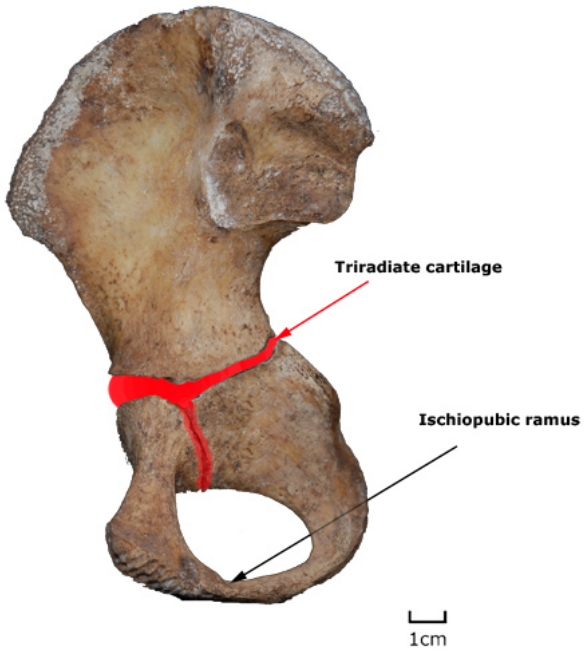
Click and drag the 6 year old innominate. Note that there is no fusion in the region of the acetabulum.

In life cartilage would appear between the three bones in the region of the acetabulum. As the acetabulum grows, the cartilage is eventually replaced by bone.

Landmarks: Ilium, ischium, pubis, acetabulum, pubic symphysis, surfaces (for example iliac fossa, gluteal surfae etc), obturator foramen.

Siding hints: When viewing the acetabulum place the iliac crest superior and the ischial tuberosity inferior. The pubic symphysis will point to the side from which the bone originates.

7. Fusion



Fusion between the ischium and the pubis occurs in the region of the **ischiopubic** ramus between 5-8years of age.

A temporary cartilaginous growth plate continues to separate the ilium, ischium and pubis in the region of the acetabulum - **the triradiate cartilage.**

8. 6 year old drag and drop activity

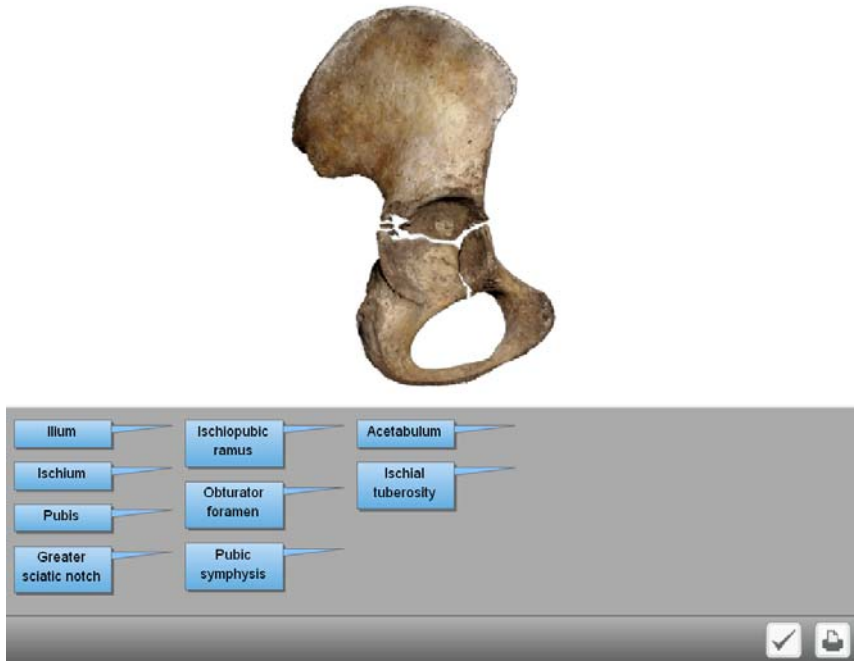
Click the link below for a labelling activity.

P9_6years.swf

The above link should open in a new window. Resize the window if desired and have a go.

Click the tick to submit answers and you will get feedback. Click the tick again to have another try.

Results will not be recorded.



9. Siding drag and drop activity

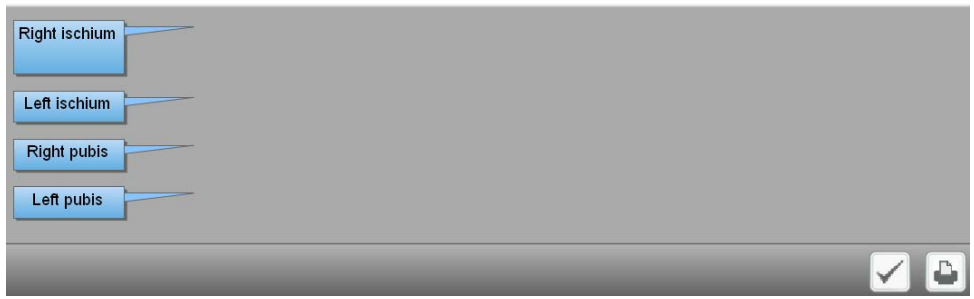
Click the link below for a labelling activity.

P7_siding.swf

The above link should open in a new window. Resize the window if desired and have a go.

Click the tick to submit answers and you will get feedback. Click the tick again to have another try.

Results will not be recorded.



10. Review

Not Reviewed

You have completed part two of tutorial 2.

Mark this page as reviewed (right) to activate part 3.

Part 3 can now be found by clicking tutorials (left) then clicking tutorial 2 part 3.

Part 3 - Secondary Ossification 1 - Maturation of the Acetabulum

Objectives:

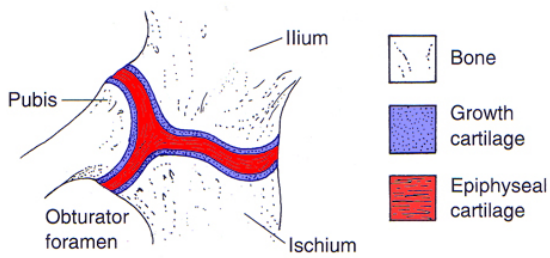
- Be able to identify the acetabular surface of a juvenile ilium, ischium and pubis
- Understand and be able to describe the cartilagenous growth plate of the acetabulum (triradiate cartilage)
- Understand and be able to describe the epiphyses involved in the maturation of the articular region of the acetabulum.

OK

1. Primary ossification

Maturation of the acetabulum is a complex process. From an early age, an acetabular surface can be identified on each of the three primary ossification centres of the innominate; the **ilium**, **ischium** and **pubis.**

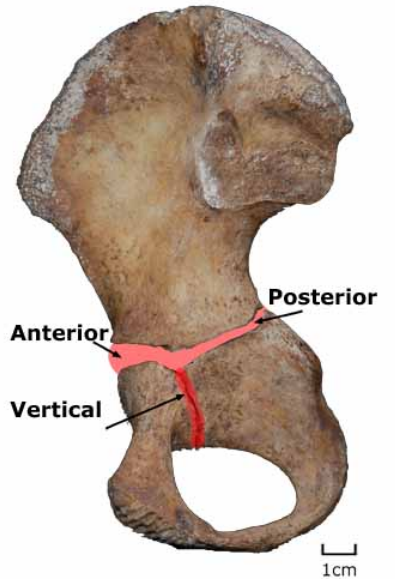
2. Secondary Ossification of the Acetabulum 1



During the development of the innominate, a cartilaginous growth plate is present in the region of the acetabulum between the ilium, ischium and pubis. This growth plate allows expansion of the acetabulum to accommodate the growing femoral head. Complete fusion of this region marks the end of acetabular growth

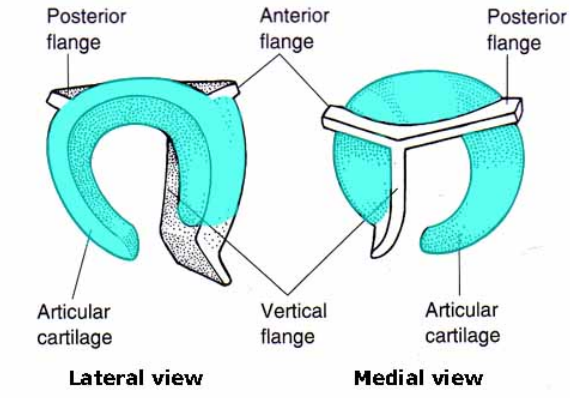
There are three types of cartilage present in the developing acetabulum; **growth**, **epiphyseal** and **articular**.

The **triradiate** cartilage consists of three flanges; anterior, posterior and vertical.



In life the red highlighted areas would be cartilage.

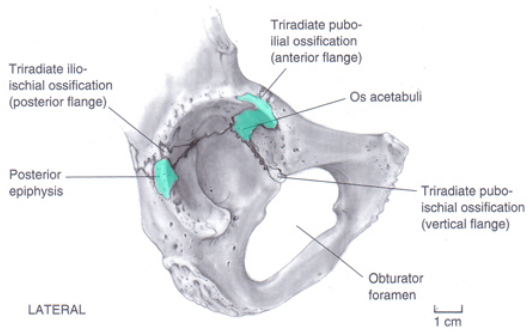
4. Secondary Ossification of the Acetabulum 3



The cartilaginous template is composed of a cupped C-shaped **articular** area connecting to the triradiate growth element (previous). These fuse with epiphyseal elements which creates the rim of the acetabulum.

5. Secondary Ossification of the Acetabulum 4

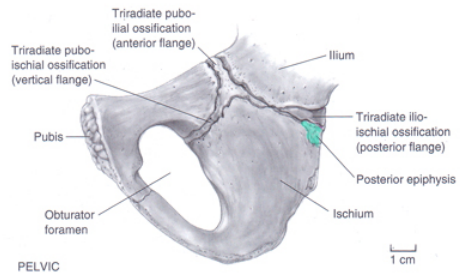
Os Acetabuli (articular)



Between 9 and 10 years of age the **os acetabuli** appears. It is the first epiphysis to appear in the region of the acetabulum. It extends towards the anterior flange of the triradiate and forms part of the articular rim.

6. Secondary Ossification of the Acetabulum 5

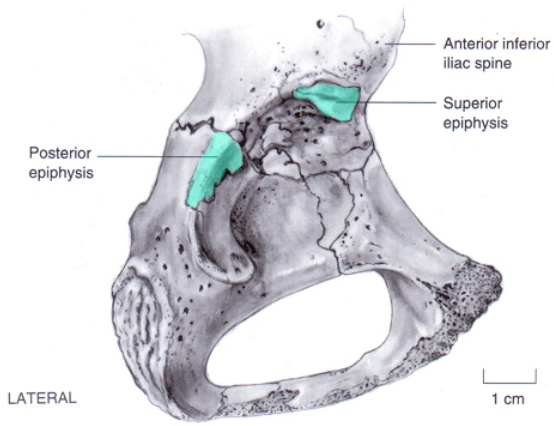
Posterior epiphysis (articular)



The **posterior epiphysis** appears between 10 and 11 years of age. It extends to the posterior flange of the triradiate and forms the posterior rim and lower articular part of the articular surface.

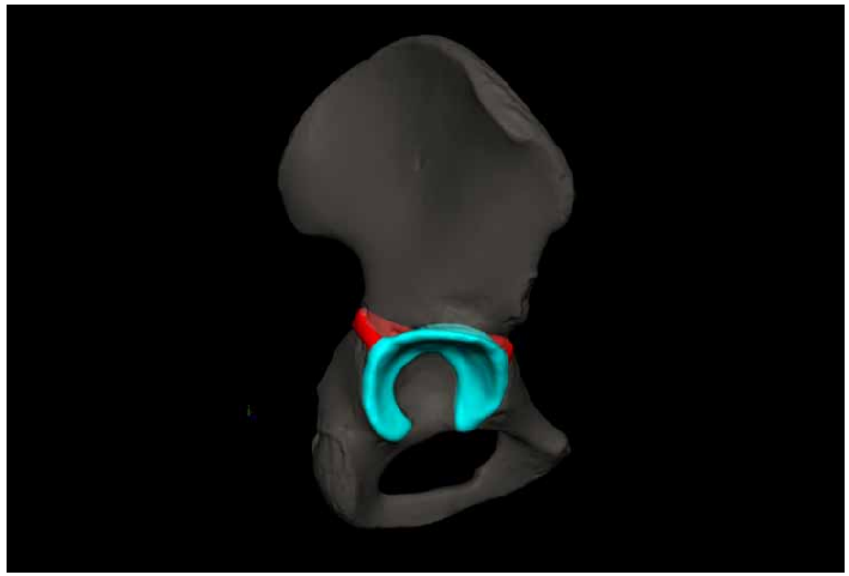
7. Secondary Ossification of the Acetabulum 6

Superior epiphysis (articular)



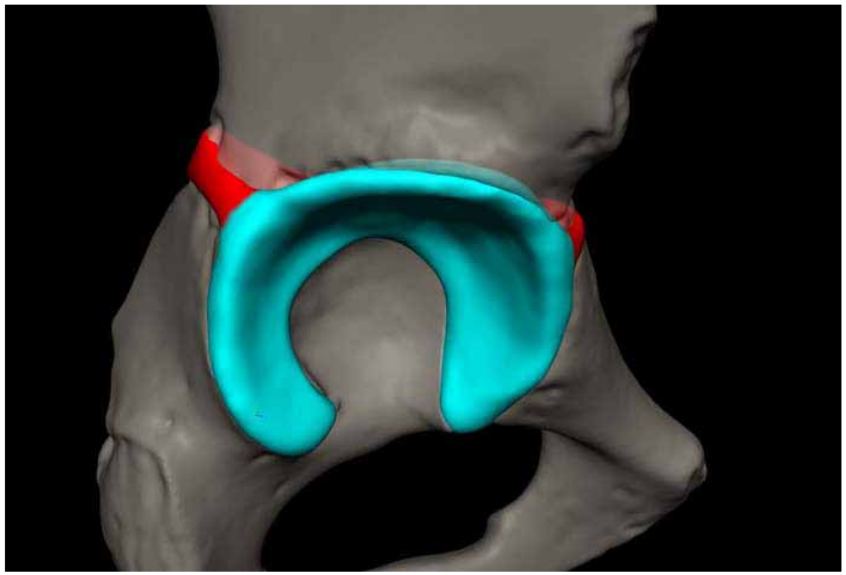
The **superior epiphysis** appears between 12 and 14 years and forms the upper part of the acetabular rim. It does not extend into the triradiate, but can extend superiorly to fuse with the anterior inferior iliac spine.

Click and drag the innominate



Note the **articular** cartilage region and the **triradiate** cartilage *in situ*

Click and drag the acetabulum



Note the **articular** cartilage region and the **triradiate** cartilage *in situ*

Around the age of 9 years the triradiate cartilage displays a number of small ossific islands which later fuse to one another. Fusion is complete by 11-15 years in females and 14-17 years in males.

Click and drag the image below, note the ossific islands of bone in the region of the triradiate and also note the epiphyses forming at the articular region of the acetabulum.

11. Maturing acetabulum drag and drop activity

Click the link below for a labelling activity.

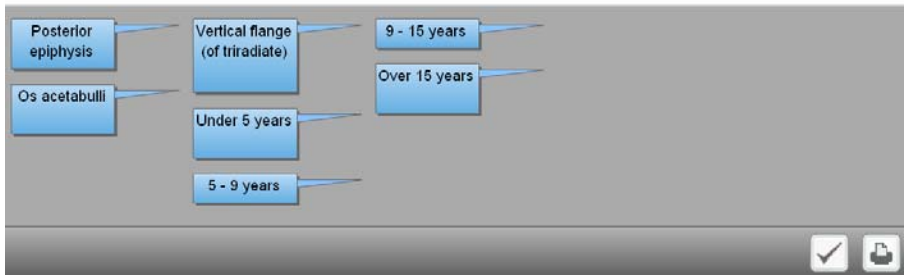
Maturing acetabulum.swf

The above link should open in a new window. Resize the window if desired and have a go.

Click the tick to submit answers and you will get feedback. Click the tick again to have another try.

Results will not be recorded.

Note: not all labels will be required.



12. Review

Not Reviewed

You have completed part three of tutorial 2.

Mark this page as reviewed (right) to activate part 4.

Part 4 can now be found by clicking tutorials (left) then clicking tutorial 2 part 4.

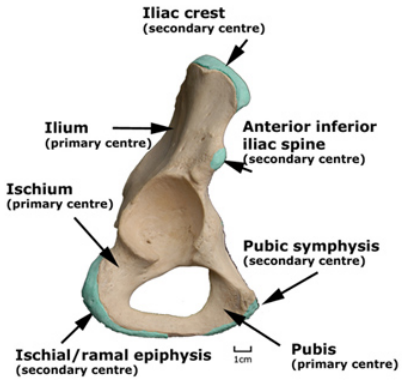
Part 4 - Secondary Ossification 2

Objectives:

- Understand and be able to describe the secondary centres of ossification of the innominate
- Understand the development of the pubic sysmphysis
- Be able to utilise knowledge of appearance and fusion times of centres of ossification (both primary and secondary) to estimate the age at death of an innominate

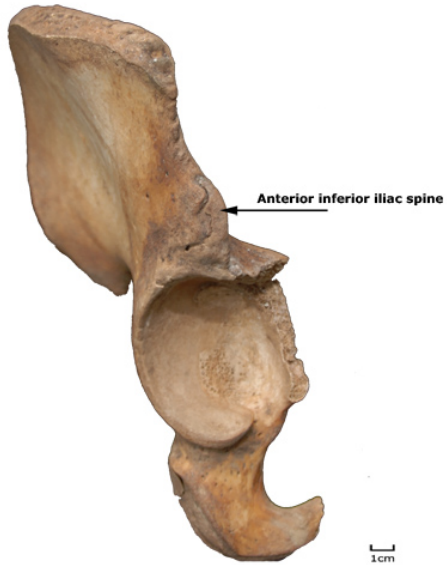
OK

1. Secondary ossification of the Innominate



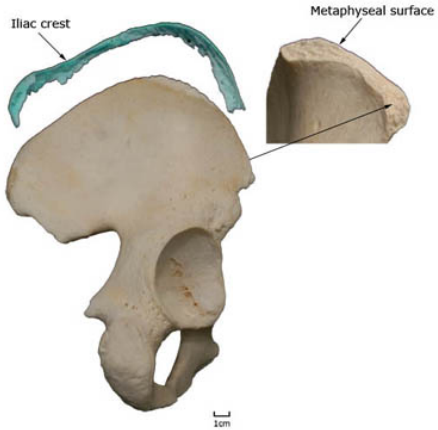
In addition to the acetabulum, there are a number of secondary centres of ossification involved in the maturation of the innominate. The appearance and fusion of these occur in a general sequence and can be used to age juvenile remains. Each **secondary centre** (left) will be discussed further in the general sequence the appear and fuse.

2. Anterior Inferior Iliac Spine



The **anterior inferior iliac spine** can arise from an upwards projection of the superior epiphysis of the acetabulum (seen left) or can appear from its own centre of ossification. It appears between 10-13 years and fuses to the ilium by 20 years.

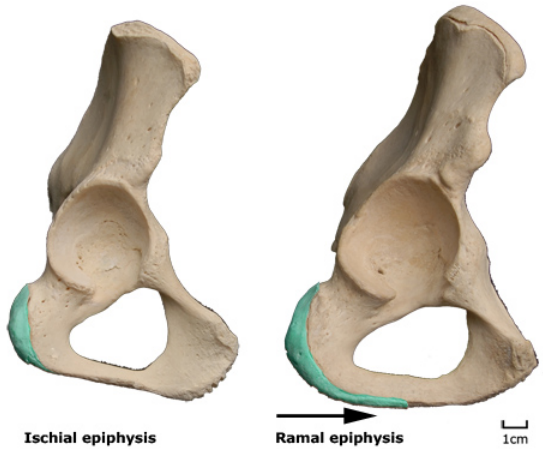
3. Iliac Crest



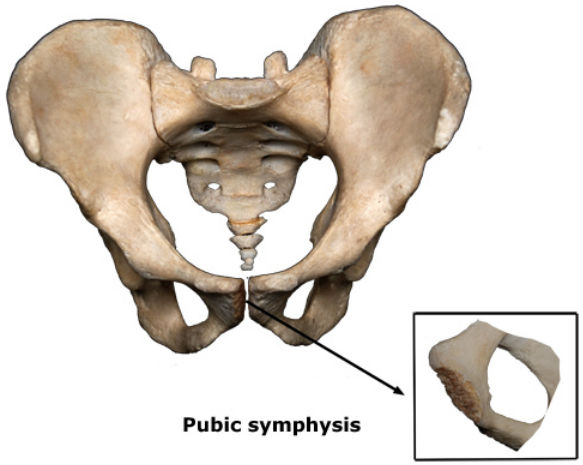
- The **iliac crest** generally forms from two centres of ossification, these appear around 12-14 years in females and 14-15 years in males. Ossification begins in the middle of the crest with one centre extending anteriorly and the other posteriorly.
- These fuse to each other at the midline between 17-20 in females and 19-21 in males. The anterior extremity becomes the anterior superior iliac spine and the posterior extremity becomes the posterior superior iliac spine.
- The surface of the ilium beneath the **iliac crest** is represented by a **metaphyseal** (growing) surface. This is seen on all primary centres where epiphyses will later fuse and is represented by a characteristic billowed appearance.
- Partial fusion of the **iliac crest** to the ilium ranges from 15-22 years. Fusion to the ilium is complete by 23 years.

4. Ischial Epiphysis (ramal epiphysis)

- The ischial epiphysis appears between 13 and 16 years as a flake-like structure in the region of the ischial tuberosity.
- It extends along the ischial ramus where it becomes the ramal epiphysis.
- This epiphysis is not an independent structure as it arises as a flake from the ischial tuberosity.
- Fusion commences around 16-18 years and is complete by 23 years.

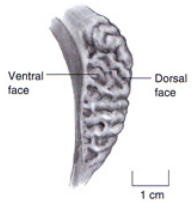


5. Pubic Symphysis 1



After puberty the pubic symphysis matures in a well documented sequence.

6. Pubic Symphysis 2

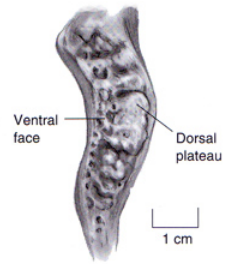


A billowed appearance is observed on the symphyseal surface until around 13 years of age.

The upper and lower limits of the face are not defined.

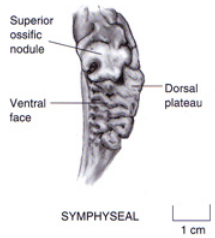
There is no build up of bone on the ventral aspect.

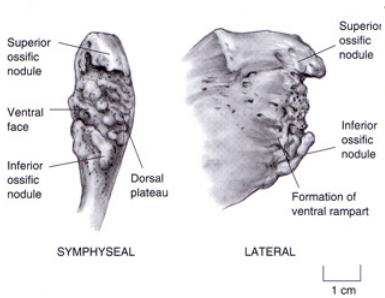
7. Pubic Symphysis 3



The billowed appearance begins to smooth on the dorsal aspect forming the dorsal plateau.

8. Pubic Symphysis 4





The ventral rampart is a built up region of bone which can be used for aging from the pubic symphysis.

Between 23 and 27 years the upper and lower limits of the symphysis are forming. The lower limit forms later.

Approximately 25 years the inferior ossific nodule forms. This forms the lower aspect of the rampart and extends superiorly.

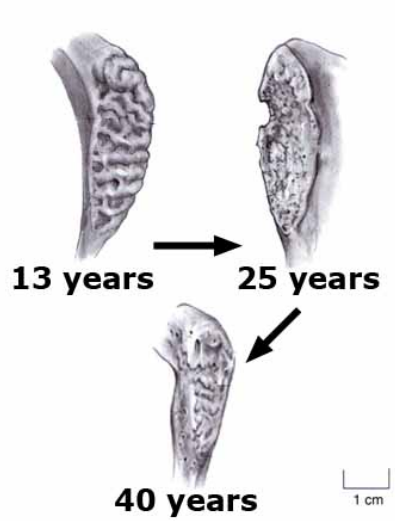
The superior ossific nodule forms shortly after and extends inferiorly creating the upper part of the ventral rampart.

The ventral rampart is said to be active at this age due to the upper and lower borders growing towards each other.

Often the rampart fails to meet in the centre leaving a hiatus.

Full maturation of this region may not be apparent until 35 years.

9. Pubic Symphysis 5



The billowed appearance on the symphysis is characteristic of the younger symphysis
(< 25 years).

A grannular surface replaces the billowed appearance of the younger symphysis.

Changes later are degenerative not developmental.

10. Pubic Tubercle

Lateral view

The epiphysis for the pubic tubercle may form from a separate flake or from a projection of the superior ossific nodule. This usually occurs between 23 and 25 years of age.

11. Aging drag and drop activity

Click the link below for a labelling activity.

Secondary_ossification.swf

Note: some labels may not be required.

The above link should open in a new window. Resize the window if desired and have a go.

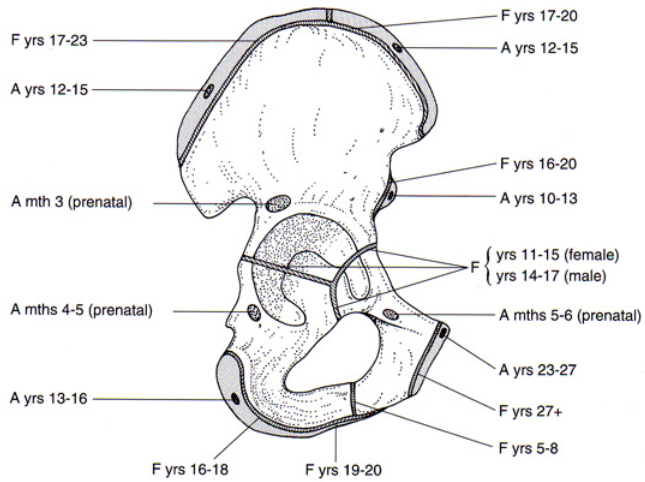
Click the tick to submit answers and you will get feedback. Click the tick again to have another try.

Results will not be recorded.

The following diagram and tables highlight key stages in the development of the innominate

Morphological Summary

Appearance (A) and fusion (F) times of the innominate ossification centres



You have completed the second tutorial.

Mark this page as reviewed (right) to activate test 2.

The test can now be found by clicking tutorials (left) then clicking tutorial 2.

Developmental Osteology Test 2

Click the link above to start the test (the timer will start straight away). The test is split into 3 sections and a time limit of 15 minutes has been set for the entire test. Please allow 5 minutes for each section. Please do not "google" or guess answers.

Once you have completed the test, an evaluation must be completed. The evaluation can be found by cicking on tutorials (left) then tutorial 2.

Developmental Osteology Tutorial 2 Evaluation

Click the link above to complete the evaluation. This does not have a time limit but should only take 10 minutes to complete.

Completion of this evaluation will activate the final evaluation, you can find this by clicking tutorials (left)

Developmental Osteology Final Evaluation

OK

Tutorial 2 - Development of the innominate

Click on the above link to start tutorial 2. It is split into 4 parts, each of which will be activated following completion of the previous:

Part 1 - Ossification. One page explaining ossiffication, will automatically be directed to part 2.

Part 2 - Primary ossification.

Part 3 - Secondary ossification 1 - Maturation of the acetabulum

Part 4 - Secondary ossification 2 and summary.

A test and an evaluation will follow part 4.

A glossary and anatomical terms pages are available for your use. These are located at all times on the left side of the screen and will open in the current window. To return to the section you were working on click the "back" button on your internet browser. In some instances there are links to these within the module, these will also appear in the same window.

Other links will open in separate windows many of which are links to journal articles, these will download automatically and may take a few moments to appear.

There are some animations which may take time to load, please be patient.

If you have any problems regarding the module please direct your queries to the discussionboard or e-mail me
k.tyldesley@dundee.ac.uk

Developmental Osteology Final Evaluation

Developmental Osteology test 1

You have 10 minutes to complete this test. The test has been split into 2 sections, please allow 5 minutes per section.

1 of 10
Is this skeleton in the anatomical position?

- Yes
- No
- Don't know

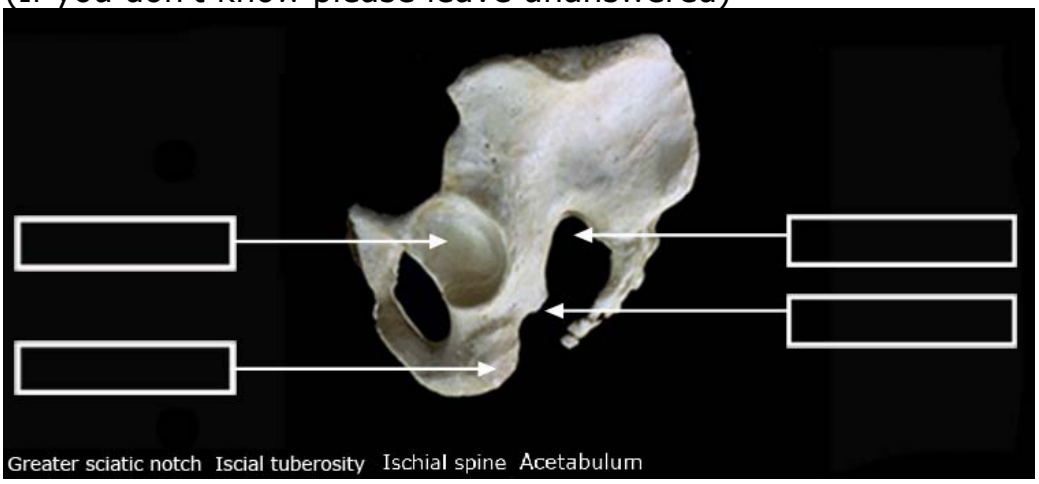
2 of 10
The innominate (also known as the hip bone or os coxae) can be palpated through skin and soft tissues.

- True
- False
- Don't know

3 of 10
Which of these contribute to the pelvic girdle?

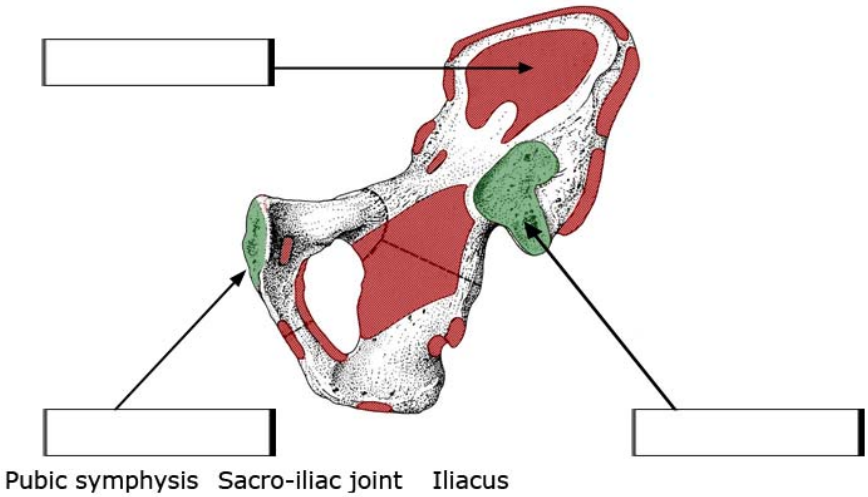
- Lumbar Vertebrae 1 - 4
- Coccyx
- Right and left innominates
- Sacrum
- Right and left Femora
- Don't know

4 of 10
Drag these labels to their bony landmark
(If you don't know please leave unanswered)



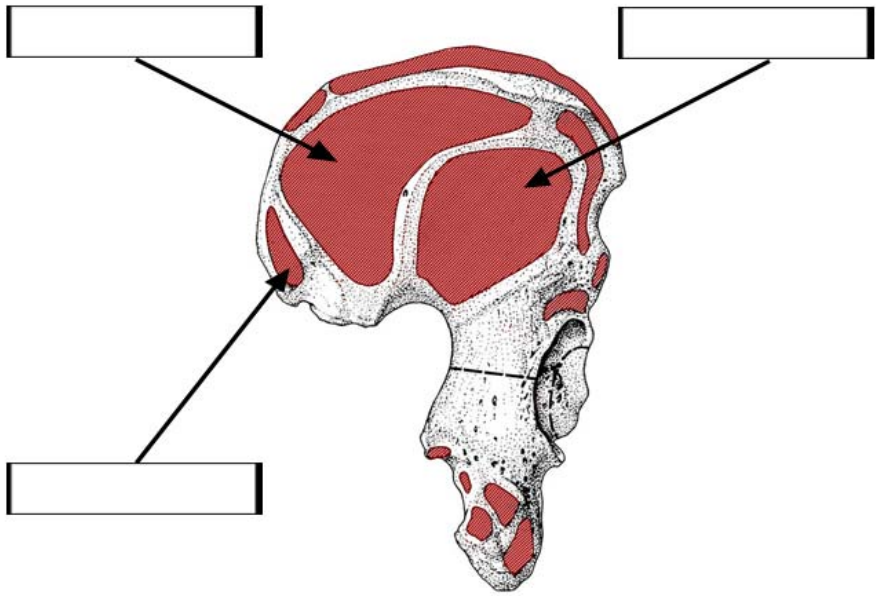
5 of 10
Define the following joints The sacroiliac joint is a - cartilaginous joint/synovial joint/ mixed joint/ don't know
The pubic symphysis is a - cartilaginous joint/synovial joint/ mixed joint/ don't know
The hip joint is a - cartilaginous joint/synovial joint/ mixed joint/ don't know
The articulation between the 5th lumber vertebra and the sacrum is a - cartilaginous joint/synovial joint/ mixed joint/ don't know

6 of 10
Drag these labels to their site on the right innominate
(If you don't know please leave unanswered)



7 of 10
The right innominate articulates with the _____ posteriorly and the _____ innominate anteriorly.

8 of 10
Drag the following muscles to their attachment
(If you don't know please leave unanswered)



Gluteus maximus Gluteus medius Gluteus minimus

9 of 10
The shape of the adult female pelvis reflects a compromise between 2 major functions _____ locomotion and safe parturition.

10 of 10
In development which of these fuse to create the innominate?

- Pubis
- Ischium
- Ilium
- Acetabulum
- Trochanter
- Don't know

SECTION 2

1 of 10

Side this innominate

- Right
- Left
- Don't know

2 of 10

The right and left innominates form part of the axial skeleton.

- True
- False
- Don't know

3 of 10

A synovial joint can be seen above.

- True
- False
- Don't know

4 of 10
The fusing epiphyses present on the iliac crest suggests

- It is juvenile
- It is adult
- Don't know

5 of 10
The most superior portion of the pelvis is the iliac crest.

- True
- False
- Don't know

6 of 10
Which bone(s) contribute to the acetabulum?

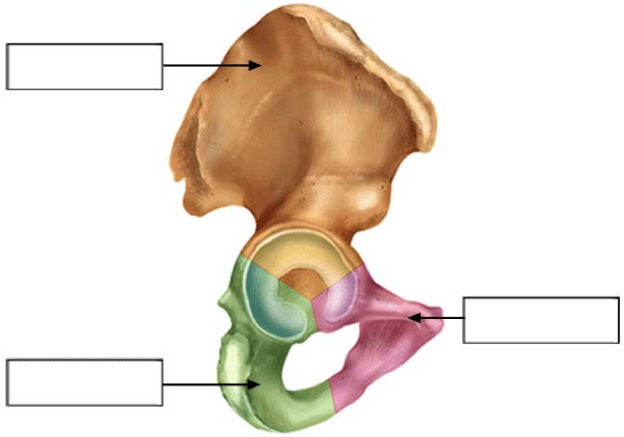
- Pubis
- Ilium
- Ischium
- Femur
- Sacrum
- Don't know

7 of 10
The inguinal ligament attaches to which bony elements?

- Anterior superior iliac spine
- Anterior inferior iliac spine
- Ischial tuberosity
- Ischial spine
- Pubic tubercle
- Pubic ramus
- Don't know

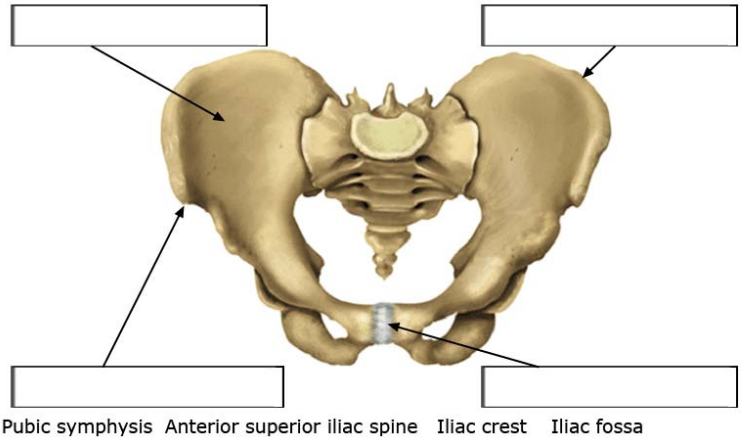
8 of 10
Assign a sex to each of the following pelves by dragging the label (Male/ Female) over the appropriate pelvis.
(If you don't know please leave unanswered)

9 of 10
Drag these labels to the appropriate bony element
(If you don't know please leave unanswered)



Ilium Ischium Pubis

10 of 10
Label the following structures
(If you don't know please leave unanswered)



Pubic symphysis Anterior superior iliac spine Iliac crest Iliac fossa

Developmental Osteology test 2

You have 15 minutes to complete this test. The test has been split into 3 sections, please allow 5 minutes per section.

SECTION 1

1 of 9

Bone is laid down in a progressive process known as _____ .

2 of 9

All three primary centres of ossification of the innominate are present at birth.

- True
- False
- Don't know

3 of 9

A primary ossification centre may form the entirety of a bone.

- True
- False
- Don't know

4 of 9

The innominate develops from both primary and secondary ossification centres.

- True
- False
- Don't know

5 of 9

Fusion of the innominate is first seen between 5 and 8 years in the region of the....

- acetabulum
- ischiopubic ramus
- superior ramus
- iliac crest
- don't know

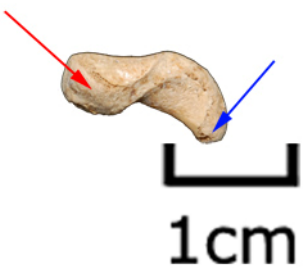
6 of 9
The primary centres of ossification of the innominate are highlighted in green.

- True
- False
- Don't know

7 of 9
Side this perinate ilium

- Right
- Left
- Don't know

8 of 9

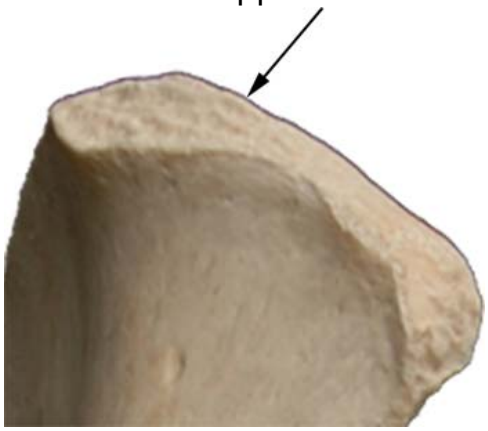


- The red arrow is pointing at the - auricular surface/acetabular surface/pubic symphysis/ischium/pubis/don't know

- The blue arrow is pointing at the - auricular surface/acetabular surface/pubic symphysis/ischium/pubis/don't know

- This perinatal bone is the - auricular surface/acetabular surface/ pubic symphysis/ischium/pubis/don't know

9 of 9
The billowed appearance of the arrowed surface indicates:



- the bone is fully matured
- the bone is still growing
- the bone shows pathology on the iliac crest
- don't know

SECTION 2

1 of 9
Secondary ossification in the region of the innominate is generally seen in which region first?

- Acetabulum
- Iliac crest
- Pubic symphysis
- Anterior inferior iliac spine
- Don't know

2 of 9
The head of the femur is an example of a secondary centre of ossification. The shaft of the femur forms from a - primary/secondary/tertiary/Don't know centre of ossification.

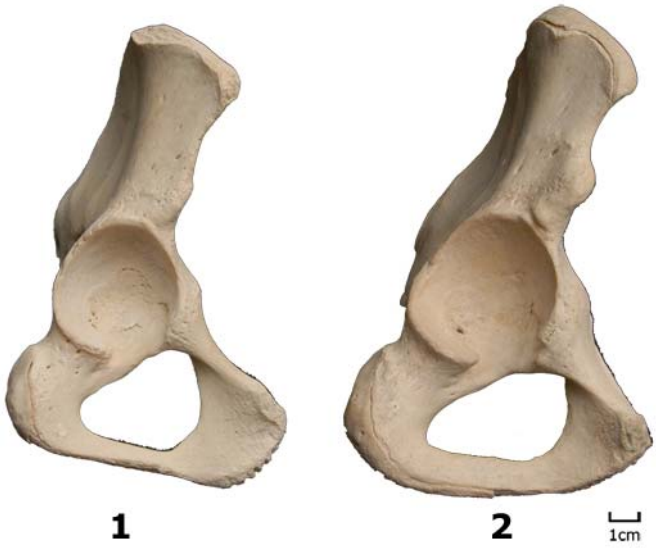
3 of 9
A secondary center of ossification can also be called an _____.

4 of 9

The iliac crest generally forms from a single centre of ossification.

- True
- False
- Don't know

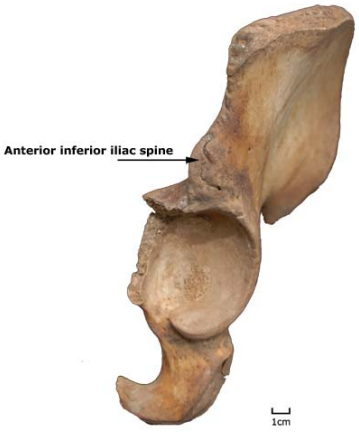
5 of 9
Which is more mature specimen 1 or 2?



- Don't know

6 of 9
As the ischial epiphysis extends anteriorly it becomes the - ramal/tuberosity/pubic/don't know epiphysis.

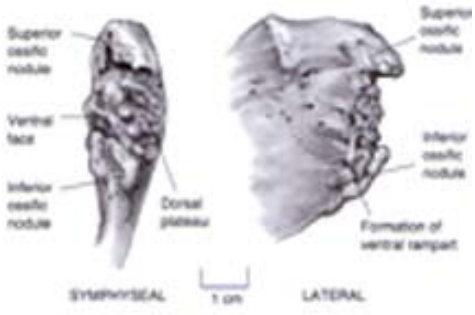
7 of 9



This centre of ossification can form from an upwards projection of which epiphysis of the acetabulum?

- Os acetabuli
- Superior
- Posterior
- Inferior
- Don't know

8 of 9
Assign an age to this specimen.



- Perinate
- 10-20 years
- 21-30 years
- 30+ years
- Don't know

9 of 9
The epiphysis for the pubic tubercle can be formed from a projection of the inferior ossific nodule.

- True
- False
- Don't know

SECTION 3

1 of 8
The acetabular surface of the ilium, ischium and pubis are identifiable at birth.

- True
- False
- Don't know

2 of 8
Which types of cartilage are involved in secondary ossification of the acetabulum?

- Articular
- Epiphyseal
- Growth
- Auricular
- Don't know

3 of 8
The first epiphysis to form in the region of the acetabulum appears between 9 and 10 years and extends to fuse with the - horizontal/anterior/posterior/vertical/don't know flange of the triradiate.

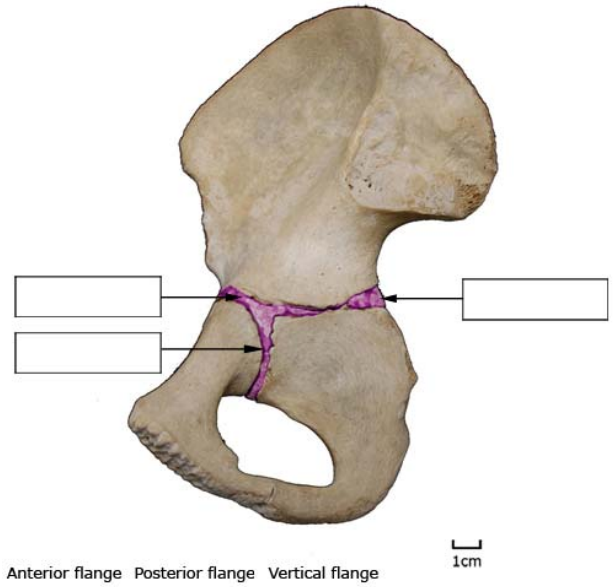
4 of 8
Name the highlighted epiphysis of the acetabulum.

- Os acetabuli
- Triradiate
- Posterior epiphysis
- Superior epiphysis
- Don't know

5 of 8
Which epiphysis does not extend into the triradiate region?

- Superior epiphysis
- Posterior epiphysis
- Os acetabuli
- Don't know

6 of 8
This triradiate cartilage is ossifying. Label each flange.
(if you don't know please leave unanswered)



7 of 8
The Os acetabuli has been highlighted?

- True
- False
- Don't know

8 of 8
How much of the content of the tests did you previously know?
None/ A little/ Moderate/ A lot/ All

Developmental Osteology Pre test evaluation

Please take the time to complete this evaluation.

1 of 10

What level are you currently studying?

○ Level 1 ○ Level 2 ○ Level 3 ○ Level 4 ○ Postgrad ○ Staff

2 of 10

Were the instructions for the test easy to follow?

○ Yes
○ No

3 of 10

How much of the content did you previously know?

○ None ○ A little ○ Moderate ○ A lot ○ All

4 of 10

How difficult did you find the questions?

○ Easy ○ Moderate ○ Hard

5 of 10

Did you have enough time to complete the questions?

○ Yes
○ No

6 of 10

Which set of questions did you prefer? If you have a preference please comment further on the discussion board.

○ 1st ○ 2nd ○ Neither

7 of 10

Were the questions clear?

○ Yes
○ No

8 of 10

Were the images clear?

○ Yes
○ No

9 of 10

How useful would this method be for revision purposes?

○ Very useful ○ Fairly useful ○ Neutral ○ Not very useful ○ Useless

10 of 10

How would you rate this as a method of examination?

○ Very good ○ Good ○ Don't know ○ Bad ○ Very bad

Submit

Developmental Osteology Tutorial 1 Evaluation

Thank you for completing the first tutorial and test. Please take 10 minutes to complete this evaluation.

1 of 13

Did you understand what was expected of you from this tutorial?

- ○ Yes
- ○ No

2 of 13

Were the instructions for this tutorial easy to follow?

- ○ Yes
- ○ No

3 of 13

How much of the content did you know before taking the tutorial?

○ All ○ A lot ○ Moderate ○ A little ○ None

4 of 13

Did this tutorial improve your knowledge of the adult innominate?

- ○ Yes
- ○ No

5 of 13

Were the images clear?

- ○ Yes
- ○ No

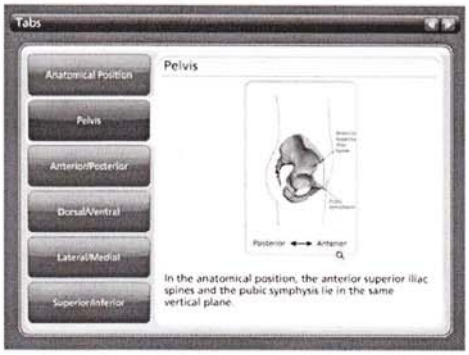
6 of 13

Did all the external links work?

- ○ Yes
- ○ No

7 of 13

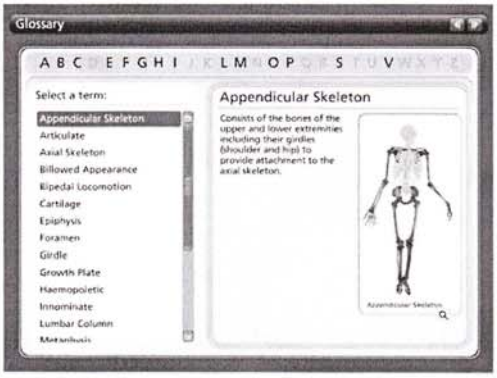
Did you use the anatomical terminology page?



- Yes
- No

8 of 13

Did you use the glossary?



- Yes
- No

9 of 13

A 3D activity was included to show the areas of the pelvis which can be palpated in life. Was this method helpful for understanding these features?

- Very helpful
- Helpful
- Neutral
- Not very helpful
- Not helpful at all

10 of 13

Would 3D activities be useful for other parts of the tutorial?

- Yes
- No

11 of 13

Did you have enough time to complete the test?

- Yes
- No

12 of 13

Were you more confident taking the test after completing the tutorial compared to taking the test before (pre test)?

- ○ Yes
- ○ No

13 of 13

Any comments?

Submit

Developmental Osteology Tutorial 2 Evaluation

Thank you for completing the second tutorial and test. Please take 10 minutes to complete this evaluation.

1 of 15

Did you understand what was expected of you from this tutorial?

- ○ Yes
- ○ No

2 of 15

Were the instructions for this tutorial easy to follow?

- ○ Yes
- ○ No

3 of 15

How much of the content did you know before taking the tutorial?

○ All ○ A lot ○ Moderate ○ A little ○ None

4 of 15

Do you understand the basic development and morphology of the human innominate bone?

- ○ Yes
- ○ No

5 of 15

Were the images clear?

- ○ Yes
- ○ No

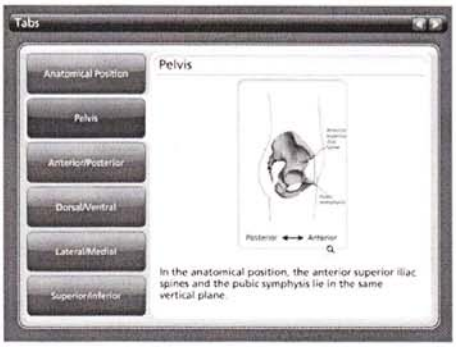
6 of 15

Did all the external links work?

- ○ Yes
- ○ No

7 of 15

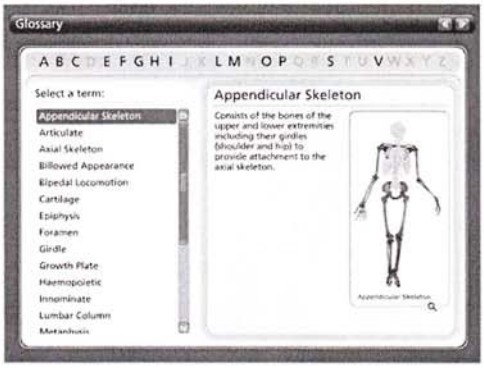
Did you use the anatomical terminology page?



- Yes
- No

8 of 13

Did you use the glossary?



- Yes
- No

9 of 13

A 3D activity was included to show the areas of the pelvis which can be palpated in life. Was this method helpful for understanding these features?

- Very helpful
- Helpful
- Neutral
- Not very helpful
- Not helpful at all

10 of 13

Would 3D activities be useful for other parts of the tutorial?

- Yes
- No

11 of 13

Did you have enough time to complete the test?

- Yes
- No

11 of 15

Would the rotating innominates be more useful with increased interactivity?

○ Yes ○ No ○ Same

12 of 15

Compared to the real specimens in the Scheuer Collection, how would you rate the 3D rotations?

(Leave question blank if you are not familiar with the Scheuer collection)

- ○ Much better than the real thing
- ○ Better than the real thing
- ○ The same as the real thing
- ○ Worse than the real thing
- ○ Much worse than the real thing

13 of 15

Did you have enough time to complete the test?

- ○ Yes
- ○ No

14 of 15

Were you more confident taking the test after completing the tutorial compared to taking the test before (pre test)?

- ○ Yes
- ○ No

15 of 15

Any comments?

Submit

8 of 17

How would you rate the 3D aspects of this module?

C Very helpful C Helpful C Neutral C Not very helpful C Not helpful at all

9 of 17

Would the inclusion of more 3D activities be more helpful for understanding the development of the human innominate?

C Yes
C No

10 of 17

Compared to the 2D images, were the 3D aspects of the module more useful for understanding the morphology of the developing innominate?

C Very useful C Useful C Neutral C Not very useful C Useless

11 of 17

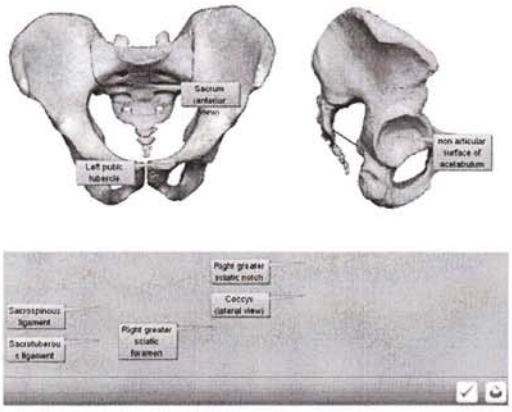
Compared to the real specimens in the Scheuer Collection, how would you rate the 3D rotations?

(Leave question blank if you are not familiar with the Scheuer collection)

C Much better than the real thing
C Better than the real thing
C The same as the real thing
C Worse than the real thing
C Much worse than the real thing

12 of 17

Were the drag and drop activities (below) useful?



C Very useful C Useful C Neutral C Not very useful C Useless

13 of 17

Was the anatomical terms feature (below) useful?

17 of 17

Any comments?

Submit